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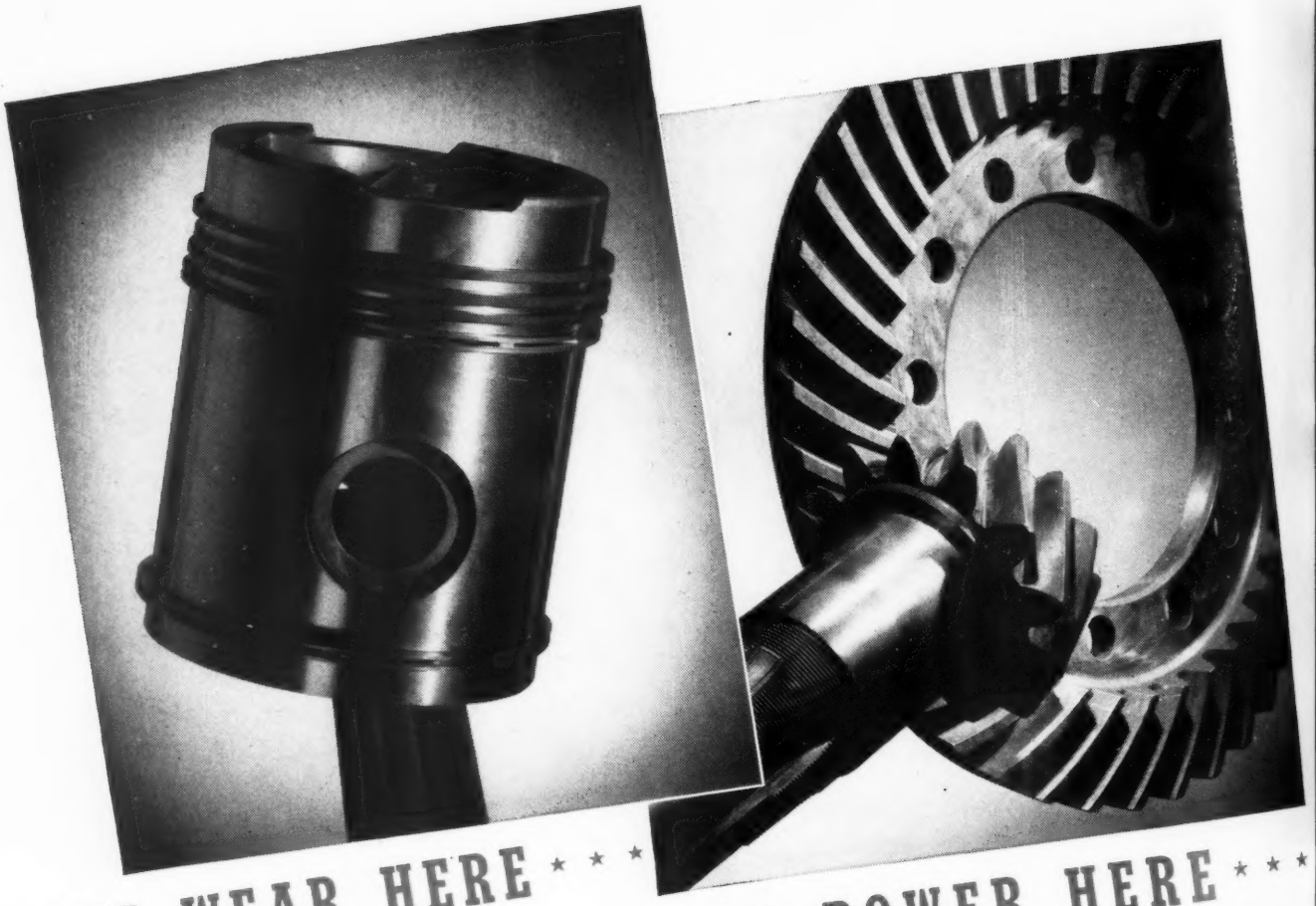

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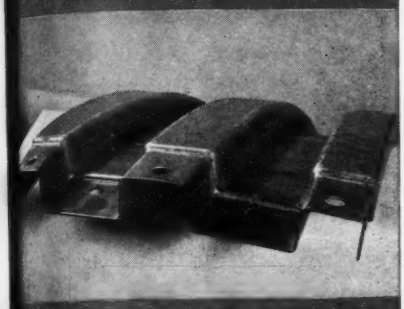

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PUBLIC WORKS

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Vol. 74 No. 6

A. PRESCOTT FOLWELL, Editor

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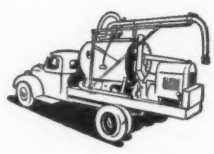
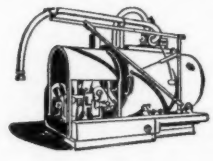
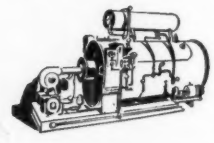




THE WAR EMERGENCY

How to Obtain Permits for Sewer House Connections

Builders are now authorized to make house and project connections to sewage facilities if they meet limits and costs set forth under the provisions of Supplementary Preference Rating Order P-141-a, and if their municipal authority addresses to WPB a letter of certification, the War Production Board announced recently.

Such a letter must certify that the project served is authorized under L-41; that the cost of the material for sewer connections is less than $1500 for underground construction or less than $500 for other construction; and that the connection is built in accordance with Housing Utilities Standards. The letter in and of itself constitutes authorization to construct sewage connection facilities. Previously, industrial and domestic customers needed direct permission from WPB.

Civil Engineers To Be Available

According to a statement made March 1 by the War Manpower Commission, approximately 7,000 civil engineers employed as of January 1, 1943, were expected to be laid off by June, 1943, and be available for replacing technical men, lost to the armed services or other war activities.

The 87,500 civil engineers in the country were engaged as of January 1, 1943, approximately as follows:

Federal Government (except Army and Navy)	8,000
State, County and Municipal Engineering Departments	18,400
Professors in Engineering Colleges	1,100
Army and Navy—Military	10,000
Army and Navy—Civilian	17,000
Construction and Contracting	22,000
Private Consulting Staffs	8,000
Industrial Organizations	3,000
TOTAL	87,500

Bituminous Road Building Machinery To Be Standardized

WPB has directed an 85% reduction in the number of models and sizes of seven types of bituminous road building equipment:

Tank car heaters are limited to one model in each of two specified sizes, and pumping boosters or circulators to one model. No rubber tires.

Paving finishers: only one 10-ft. model, with cut-off and extension attachments.

Distributors: one model in each of two specified sizes and types—800 gal. and 1250 gal. capacity; each size can be trailer or truck mounted. Distributor pumps limited to one type.

Heating kettles: One model in each of four sizes—30, 80, 110 and 165 gal. capacity. The following prohibited except for the armed services: rubber tires; more than one draw-off cock; mercury type thermometers; power spray attachments; barrel warming hoods; barrel hoists; more than one burner shut-off valve; mud guards.

Sprayer, utility or tank units: One model in each of the following sizes—120, 300 and 600 gal. capacity, all two-wheel mounted; pumps limited to those with rated capacity of not more than 100 gal. per min.; rubber tires prohibited except for the armed services.

Patch plants of specified types limited to one model in each of two sizes—10 tons per hour capacity, and between 15 and 30 tons per hour.

Surface heaters: Limited to only one model 4 x 6 ft. in size.

The reductions above described will, it is estimated, save 6% of the steel and copper previously used annually, and increase the industry's productive capacity by 20%, and liberate critical machine tools and manpower for the production of other war items.

Standardization of Vitrified Sewer Pipe

Members of the Vitrified Clay Sewer Pipe Industry Advisory Committee, meeting with officials of the War Production Board in Washington, recommended the issuance of a limitation order restricting the manufacture of vitrified clay sewer pipe to the sizes and specifications set forth in Federal Specifications SSP-361-a, Tables I and II.

It was pointed out that a research program has been instituted to develop the possibilities of vitrified clay pipe for internal pressure lines.

No Power Cranes or Shovels Available

WPB announced on May 22 that practically the entire estimated output of power cranes and shovels up to the close of 1943 will be absorbed by military orders, except certain sizes needed in mining, logging and other essential civilian work. "Used equipment should take care of most other civilian requirements if full utilization is made of all available supplies."

Planning for Next Winter's Snow Plows

WPB, after canvassing all State, county, township and municipal highway agencies, estimated that the snow plow equipment needed by them for next winter will require 1,745 tons of steel (60% of last year's requirement, in the form of cutting edges. The Snow Plow Industry Advisory Committee suggested that cutting edges be made in only 2 standard sizes—½ x 6 in. and ½ x 8 in.; the use of a standard carriage bolt, the bolt holes to be square and placed to agreed-upon patterns; and that bevelling edges be abandoned as involving unnecessary mill work.

Effect of Speed on Tire Wear

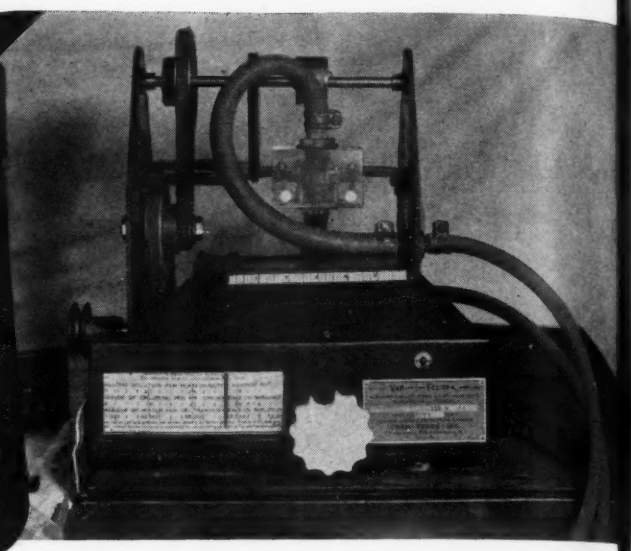
The Office of Defense Transportation is conducting tests to determine tire wear on over-the-road trucks under various speed limits. These were started April 28 and will be concluded about July 1. Meanwhile motor carriers making emergency deliveries to the Army, Navy, Maritime Commission and War Shipping Administration may exceed 35 miles per hour provided they display V Emergency Pennants and carry Certificates of Exemption; but must obey state and local laws.

Automotive Engineering Applied to Chemical Feeders

RESULT:

VAR-I-FEEDER

The Most Compact, Conveniently Operated, Low Cost Portable Chemical Feeder . . .



Var-I-Feeder removed from case. Note small compact size, accessibility for repairs and adjustments, finger-tip dial control, illuminated instrument type panel, visible illuminated reagent head, streamlined through-flow, and external pulley for belt connection to gasoline engine or available R.P.M. if current for motor drive (1/20 H.P.) is not available.

★ ★ ★

AUTOMOTIVE ENGINEERS reduced the weight and cost of motor cars and increased their efficiency by designing HIGH-SPEED engines. Chem-Feeds, Inc., a new company formed by PIONEERS in proportioning, has applied the same principle in designing Var-I-Feeder, a sensational new portable apparatus for water main sterilization, for military use, or for all chemical treatment.

This apparatus pumps over 200 "shots" per minute as compared with the conventional 10 to 40 "injections", thus approximating a continuous stream. It is as convenient to carry as an overnight suitcase and stacks readily, one atop another, in storage.

While it costs less to buy and to maintain than conventional feeders, it sacrifices nothing in efficiency or durability. On the contrary, it offers many startling improvements in design. For instance, it has finger-tip control of speed and feed while operating. As simple as tuning in your radio.

Where portable emergency main sterilizers, hypochlorinators, or other easily transported chemical feeders are in demand, Var-I-Feeder is the "watchword".

Our new circular gives many more details. Write for it.

JEFF CORYDON, *President*

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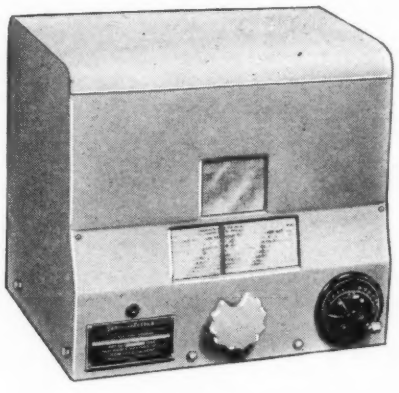

A permanent type of casing for indoor installations. Timer dial at right of panel is for attachment to water meters for proportional control.

ILLUSTRATING EXTREME PORTABILITY

VAR-I-FEEDER IN OPERATION

PUBLIC WORKS Magazine . . . June, 1943

Vol. 74. No. 6

Long-radius curves in pipe cause less loss of head than do short bends.

Hydraulics Simplified

A condensed and simple statement of the principles of hydraulics as applied to waterworks problems, with examples of such application.

1. Many problems in hydraulics arise, even in small water works or sewerage systems, where consulting engineering advice is not available, but where reasonably accurate information on the volume of flow, or on the carrying capacity of a water main or sewer pipe, is necessary. Many textbooks on this subject are available, but nearly all of them are highly technical and therefore difficult for use by the non-engineer superintendent or the engineer who has become rusty in mathematics. As a matter of fact, hydraulics is not an exact science, for actual flow in pipes may vary considerably from the results computed even by the most reliable formulas that have been developed. Moreover, the exact amount of water that will have to be carried is rarely known. Therefore it is possible to use simplified formulas, tables that permit direct reading of answers to problems, and charts, which do not require a familiarity with higher mathematics but which will give results that are accurate enough for nearly all practical purposes.

In addition to the simple formulas, tables and charts which can be used to solve the common problems in hydraulics, this article will give explanations, definitions of terms, and their correct usage. References will also be made to handbooks and other texts that will supplement the material given here.

2. Since an undue appearance of accuracy is misleading, data given in this article will ordinarily be to only two significant figures. For instance, a meter is 3.2808 feet or 39.3696 inches, but where used in this text, a meter will be considered to be 3.28 ft., or 39.37 ins.

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3. Units of Length and Weight.—In the United States, Canada and England, the foot and the inch are the standard primary units of length. In most other countries the meter, which equals 3.28 ft. or 39.37 inches, is the standard unit of length. The meter is divided into centimeters, 100 of which equal a meter; and millimeters, each of which is one-tenth of a centimeter or 1/1000 of a meter. Therefore a centimeter equals 1/100 of 39.37 ins. or about 0.4 inch; and a millimeter is about 0.04 inch.

Also in the United States, Canada and England, the pound and the ounce are standard units of weight. In those countries that use the metric system, the kilogram is the standard unit of weight. The kilogram (meaning 1000 grams) is equivalent to 2.20 pounds. A gram therefore is 1/1000 of a kilogram or about 1/30 of an ounce. In laboratory work, milligrams are used, which are 1/1000 of a gram or one-millionth of a kilogram.

In the United States, the inch and fractions of an inch are commonly used in indicating pipe and equipment dimensions, as 3-inch pipe, ⅝-inch bolt, etc. However, in using hydraulic formulas, dimensions such as sizes of pipe, orifice openings and depth of flow over a weir must be expressed in feet or decimals of a foot. For instance, in such hydraulic formulas, 15-inch pipe is 1.25-ft. pipe, 6-inch pipe is 0.5-ft. pipe; and 8 inches of head over a weir is 0.67 ft. of head.

4. Units of Liquid Volume.—(a) The gallon is one of the standard units of liquid volume in the United States. The same term "gallon" is also used in Canada and England, but it refers to the Imperial gallon which is 20% larger than the United States gallon. In this article, reference will be made invariably to the U. S. gallon, which contains 231 cubic inches and weighs (at standard temperature) 8.34 pounds. This weight is fairly constant under all usual conditions, but varies slightly with the temperature of the water. An Imperial gallon weighs 10.0 pounds. There are 1,728 cubic inches in a cubic foot and 231 cu. ins. in a U. S. gallon. Therefore there are 1,728 ÷ 231 = 7.48 U. S. gallons in a cubic foot.

The gallon is used mainly to express volumes of municipal water supply or sewerage; for instance, a reservoir holds 1 million gallons, or the sewage treatment plant is designed to treat 1.5 million gallons per day, or the elevated tank has a capacity of 200,000 gallons.

(b) The cubic foot contains 7.48 gallons and weighs (at standard temperature) 62.4 pounds. This weight is sufficiently accurate so that it can be used in all hydraulic computations, though there is some variation with the temperature of the water. The maximum density and therefore the greatest unit weight occurs at 39.3° F, at which temperature a cubic foot of water weighs 62.424 pounds; at 32° F, the weight is 62.416 pounds; at 100° F it is 62.0 pounds; and at 212° F it is 59.84 pounds. Sea water is heavier and ordinarily weighs about 64.1 pounds per cubic foot.

The cubic foot is a convenient method of measuring water in relatively small quantities. In some cities, water rates are based on the number of cubic feet sold (though many sell by the gallon). While convenient for expressing tank or reservoir capacities, these are more commonly expressed in gallons. The most common employment of the cubic foot for measurement is in connection with time factors which will be discussed in Par. 6.

(c). Metric Measurements.—The liter is the standard unit of volume in those countries using the metric system. Roughly, the liter is slightly less than a quart (0.946 quart = 1 liter). The large volume metric measurement unit is the cubic meter (or stere) which equals 35.3145 cu. ft. or 264.15 gallons. In Latin countries, including South American nations, water plant and reservoir capacity are normally given in cubic meters. These are converted to cubic feet by multiplying by 35.3 and to gallons by multiplying by 264.2.

5. Storage Measurements. — Though both gallons and cubic feet are used, the acre-foot is the standard most commonly employed for storage measurement. The acre-foot represents an acre of area 1 foot in depth. Since an acre contains 43,560 square feet, an acre foot equals 43,560 cu. ft. or 325,829 gallons (43,560 x 7.48 = 325,829). Reservoir storage capacity is normally stated in acre-feet, especially in the case of large reservoirs.

Example.—A reservoir has an area of 250 acres and an average depth of 8 feet. Its capacity is 8 x 250 = 2000 acre-feet.

Allowance must be made in computing reservoir capacity in this way for the slope of the sides. The surface area is generally much greater than the area 5 or 10 feet below the surface.

6. Volume-Time Measurements.—When a continuing flow is to be measured, a time period also must be stated, as 1 cubic foot per second, 449 gallons per minute or 646,300 gallons per day. All of these are equal, since 1 cubic foot equals 7.48 gals. and there are 60 seconds in a minute, and 7.48 x 60 = 448.81. There are 60 x 24 or 1440 minutes in a day, and 448.81 x 1440 = 646,300.

(a). Cubic feet per second, abbreviated cfs., often also abbreviated second-feet (in England and some English Dominions *cusecs)* is used mainly to express the rate of flow in rivers, canals and storm sewers. The value in terms of gallons per second, minute and day is given in the preceding paragraph.

(b). Gallons per minute, abbreviated gpm., is most commonly used to designate pump capacities. Gallons per minute x 1440 = gallons per day. For instance 700 g.p.m. x 1440 = 1,008,000 gallons per day, or roughly 1 million gallons per day.

(c). Gallons per day, abbreviated gpd., is used in rating waterworks capacities, water demand or water use. Often it is used as millions of gallons per day, abbreviated m.g.d.

(d). The miner's inch is a term used mainly in the west. As formerly used, the standard varied among the different states. In general this term designated the amount of water that would pass through a 1-inch square opening under a head which varied, in the different states, from 4 to 6½ inches. The amount has now been quite generally fixed by law and is 0.02 or 1/50 cfs. in most midwestern states, and 0.025 or 1/40 cfs. in the far western states, except Colorado which uses 0.026 or about 1/38 cfs.

(e). Inches of runoff is frequently used to indicate the yield of drainage areas, and the time factor is usually the year in this case. In measuring the runoff from very intense storms, the term "inches of runoff per 24 hours" may be used. In storm drainage design, the runoff may be indicated in inches per hour, in the same way that rainfall is indicated; however, due to the relationship between inches of rain and cubic feet per acre of runoff, the runoff is most often shown in cfs. The relationship mentioned is as follows: 1 inch of rain = 1/12 ft.; there are 43,560 sq. ft. in an acre; therefore 1 inch of rain per hour amounts to 43,560 ÷ 12 = 3630 cu. ft. per hour. Since there are 60 x 60 = 3600 seconds in one hour, 1 inch of rain per hour on

(Continued on page 28)

Using Power Patrols in Tandem for Heavy Grading

By D. R. SAVAGE
County Engineer, Aitkin County, Minn.

How, with only two patrols and two trucks available, the county converts flat, muddy or snow-drifted roads to raised 24-foot surfaces with adequate side ditches.

D. R. Savage.

OUR county—Aitkin County, Minnesota—is in a cut-over region that has not yet become more than 15 percent agricultural, and the other 85 percent has not yet grown up to timber. For fifty years we have lived in the glory of the past lumbering days. But now we are beginning to wake up.

With the advent of gas tax funds and state aid, our county took over a lot of roads to be maintained at county expense. They had been built in the past on the township plan of filling up a hole here from dirt gotten wherever handiest. The result was that the side ditches were only a succession of borrow pits and water did not run away, it soaked away—and soaked up the roads in the operation.

A narrow road with brush on the sides, no drainage in wet weather and a snow trap in winter, became a "bottle-neck," and miles of good road on each side were of no use unless the bottle neck was removed. Removing such "bottle-necks" has been our most interesting work in this time of limited funds. (A tabu has been placed on outstanding warrants.)

Our aim is a 24-foot top, with a ditch on each side that will carry water somewhere and wide enough to hold most of the snow that we plow off. We plan on a backslope of 1 to 1, a bottom width of eight or ten feet, and a depth of at least three feet; which leaves us room for a 3 to 1 side slope if we use all 66 feet of the right of way. Of course these specifications can be varied to suit conditions.

Diesel patrol graders working tandem on heavy ditch work.

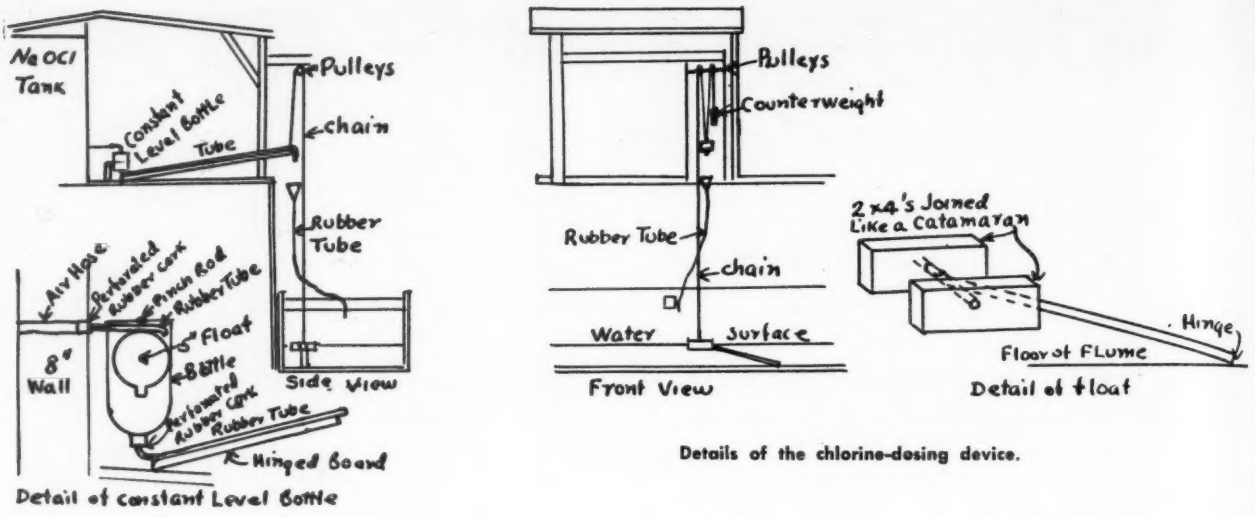
We have available two 14-foot Diesel patrols, a couple of trucks and plenty of hand tools.

We need the "go ahead" sign from the commissioner, a modest survey, a sketch showing the grade of the ditches, right-of-way stakes every station with a hub to measure depth from, a couple of willing operators as anxious to get a bad spot fixed as we are, a couple of helpers, and a spell of good weather.

Given these, we will cut and burn the brush, then start pulling in dirt from the sides and picking out roots and roots and roots. (Not much brush or roots will be left after we have those wide ditches.) If the patrols slide sidewise, we hitch one ahead of the other in getting dirt up onto the grade. From time to time we "Bulldoze" the high spots down to the low ones, using the patrols.

(Continued on page 57)

Another view of tandem patrols on heavy ditch work.



Details of the chlorine-dosing device.

Improvised Sewage Treatment

By HARRY FRANKLIN PORTER, C. E.
Ex-Major, QMC, Construction Division

CONFRONTED at one of the new army cantonments which has been designed, built and occupied within the past nine months, with the problem of receiving and treating in a manner not objectionable to the jurisdictional public health authority the sewage of an indeterminate number of troops scheduled to occupy the post in part far in advance of the most optimistic expectation of completion (indeed, before even the plans were complete), it was early realized that some definite scheme of temporary treatment was an absolute necessity. How this was accomplished it is the purpose of this article to describe.

Secondary treatment was in order, in view of the unavailability of any sizable body of running water permitting discharge with only primary treatment. The nature of the soil was such as to dismiss sand beds from consideration at the outset. Another limitation was the relative flatness of the only available site for the treatment plant; a gently sloping area below the railroad area of the post, mostly marsh land, through which the immediate effluent water-way had, in dry weather, no clearly defined course. (This had to be ditched to define its bed as to both line and grade, and at the same time was relocated.) Deep stone filters likewise were unfeasible except with additional pumping. Accordingly, choice narrowed to the Bio-Filtration process, using shallow, high-rate trickling filters with progressive recirculation. This system, too, appeared to offer advantages both in time of construction and in first cost. It is expected to yield an effluent containing not more than 35 ppm of suspended solids and not more than 30 ppm of BOD.

Contributory population is expected to vary from a few thousand to 20,000 or more. The original rating was 20,000, but this has since been raised to 30,000, contingent upon additional latrine facilities being provided. The plant was proportioned to handle a daily flow of 1.61 mg, peaking at 4.3 mg. Current army standards would require, for 20,000 population, 1.5 mgd, with a peak of 4.575 mgd; the corresponding 16 hr. average flows being 2.1 and 1.875, and the 4 hr. maximums 3.45 and 2.625 respectively. If the army standards are borne out in practice, then the plant as designed should readily take care of the larger population and still yield a very good effluent. To date, after nearly 7 months of operation, the population has never much exceeded 9,000 and this fact has simplified the problem of provisional treatment.

In order to suit the requirements of recirculation and at the same time achieve the highest practicable degree of flexibility in operation, the plant was designed in duplicate, with two each identical primary clarifiers, bio-filters, secondary clarifiers, and digesters. Grit, screening, and chlorine-contact chambers are also dual, though each pair is in one structure. Only the diversion chambers, four in number, and the Parshall flume are single, serving both sets of units. The B-F effluent is methodically returned in part (about 50%) to the 1st control chamber, itself an adjunct to the screening chamber, there mingling with the screened raw sewage, the secondary sludge (returned by pumps from the secondary clarifiers), and the supernatant or digester overflow liquid (returned by gravity); the mixture comprising the primary clarifier influent.

Similarly, there is returned (by pumping) to the diversion chamber (DC-2) feeding the bio-filters (there mingling with the primary clarifier effluent) all of the secondary clarifier effluent except the portion continuing to flow on through the Parshall flume (in theory equal in quantity to that of the raw influent), thence into the chlorine-contact chamber and on through 235 ft. of 24" outfall to the brook.

All settleable solids are thus concentrated in the primary clarifiers, whence they are withdrawn (via

How a Bio-filtration plant at an army camp for 30,000 men was put into partial operation months before it was possible to complete it. Ingenious use of temporary devices minimized use of critical materials.

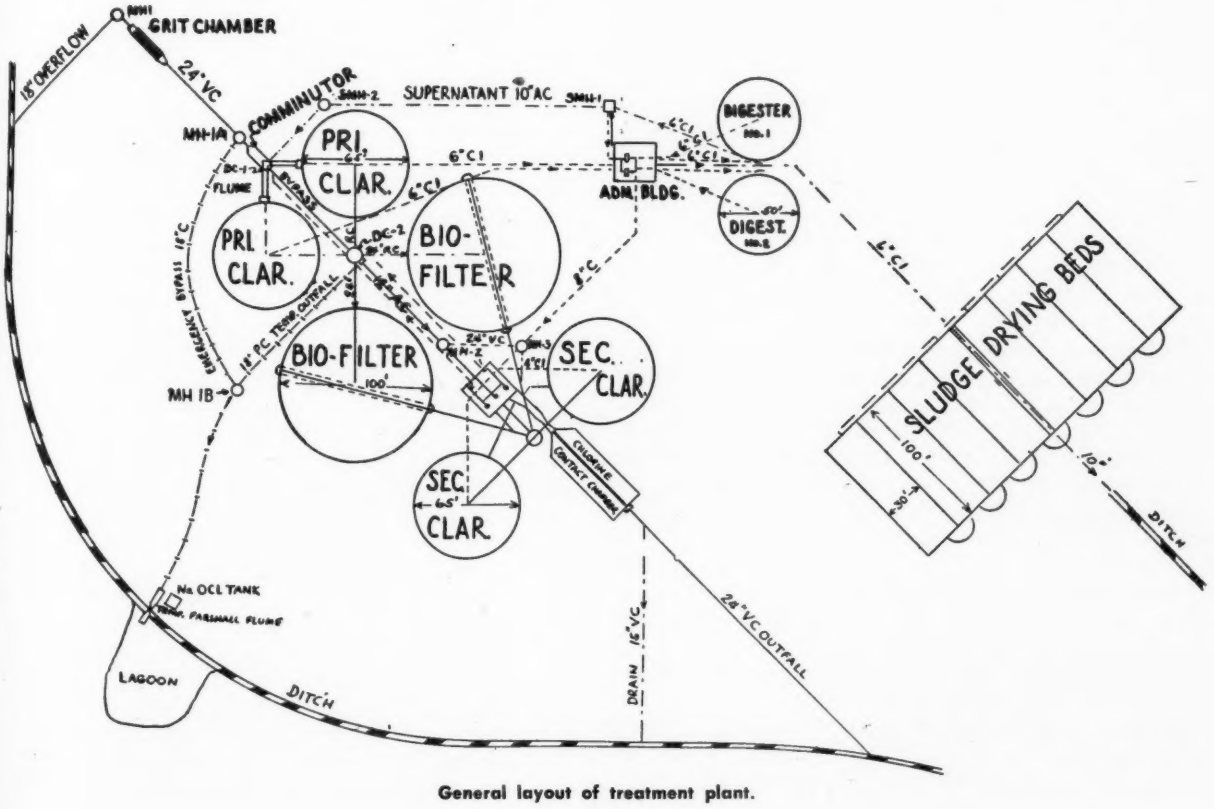
Army Camp

pumps) to the digesters. Digested sludge in turn is drawn off (by gravity or by pumping at option) to drying beds, eight in number, aggregating 24,000 s.f. These are underdrained, the filtrate discharging into the same brook below the outfall confluence.

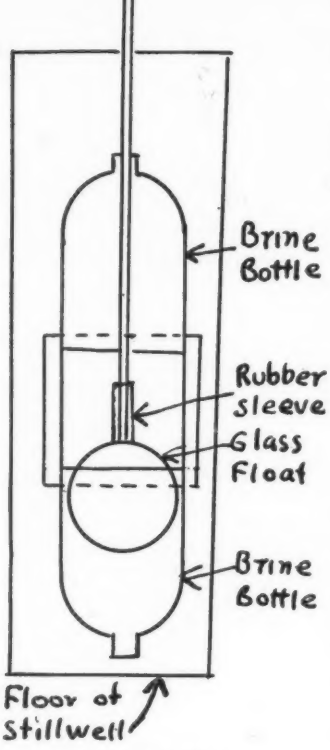
There is provision for post-chlorination only. The apparatus is in the recirculation pump house located on the plant axis about midway between the bio-filters and the secondary clarifiers. Application of the chlorine solution is just ahead of the jump in the Parshall flume. The rate of dosing is controlled by a float in a still-well in the basement of the building, connected to a well at the 3rd point of the converging section of the flume. Another small still-well, served by the same water-level transmitting pipe, operates the float controlling the measuring device, which is of the indicating, recording and totalizing type, also within the building.

The primary sludge pumps, likewise in duplicate, are located in another building fairly close to the digesters. On the same level (basement) are the gas furnaces (two) for utilizing the digester gas to heat water to supply the coils in the digesters, calculated to maintain the digesting sludge at 90° F. or thereabouts. A third furnace, coal-fired, intended primarily to heat the building when and if no gas is being generated, provides hot water for the digesters during starting-up periods, before sufficient gas is being generated. Gas is also piped to the (completely equipped) laboratory on the first floor. Excess gas is waste-burned, the burner being housed in a masonry stack so as to conceal the flame and avoid wasting it unburned during any blackout periods. On the first floor also is the operating office and toilet and locker room. In the office is located the signal panel communicating with all power-operated units, showing green when operating smoothly, red when in trouble, when an overhead gong also is sounded. This panel carries also start-and-stop push buttons controlling the clarifiers (also locally controlled).

The operating office (housing the sludge pumps and gas-utilization equipment) was located close to the digesters so as to have all valve control in the building, thus dispensing with the more usual in-between control chamber, difficult and costly to construct and with limited operating space.



General layout of treatment plant.



Gauge for Parshall flume.

All four clarifiers are sized for a detention of 2½ hrs. at average flow, or, including recirculation, 2.1 mgd each. The B-F's were designed for a BOD rating of 1.58 lbs. p.c.y.; and the digesters for a sludge storage capacity of 85,000 c.f., which, for 20,000 population, is at the rate of 4.25 c.f.p.c. and for 23,000, 3.75. The digesters both have fixed domes, with no provision for storage of gas. Had it not been for the War Department's mandate to economize the use of steel, the design probably would have included the customary three units, two with fixed domes and one, a secondary, with a floating cover containing a holder.

In addition to all of the above, constituting the permanent plant, the design provided for two lagoons—one to serve as a chlorine-contact basin during the expected period of temporary operation giving primary treatment only; the other, to receive the raw sludge until such time as the digesters were ready. The former was located adjacent to the effluent brook above the confluence of the outfall, opposite the second diversion chamber; the other, below the drying beds, so that the same pipes, extended, could serve to deliver the sludge. The sludge draw-off pipe from one of the primary clarifiers (PC-E) was purposely laid low so as to pass under the pump room floor, permitting hydrostatic draw-off of the sludge to the sludge lagoon until such time as the pumps were ready. At the time, it was contemplated that one, at least, of the primary clarifiers (PC-E), along with its effluent receiving chamber (DC-a), would be ready on or before the date appointed for occupancy of the post; and during this period of primary treatment to dose both with lime as a precipitant with chlorine.

The design further had in mind the use, during the period of partial treatment, of a small pond into which the brook develops about a mile below the plant, a few hundred feet from where it flows into a river that drains about 85 s.m., which in turn flows into a major stream outletting to the sea. This pond was cleaned out and stop-logged at the lower end, increasing the pondage to provide at least 12 hrs. detention at maximum combined flow (storm and sanitary). It was also believed that this pond would serve a useful purpose for the duration, should the completed plant at any time be over-taxed, requiring partial by-passing of raw sewage, or in part only primary treatment, during daily periods of maximum flow.

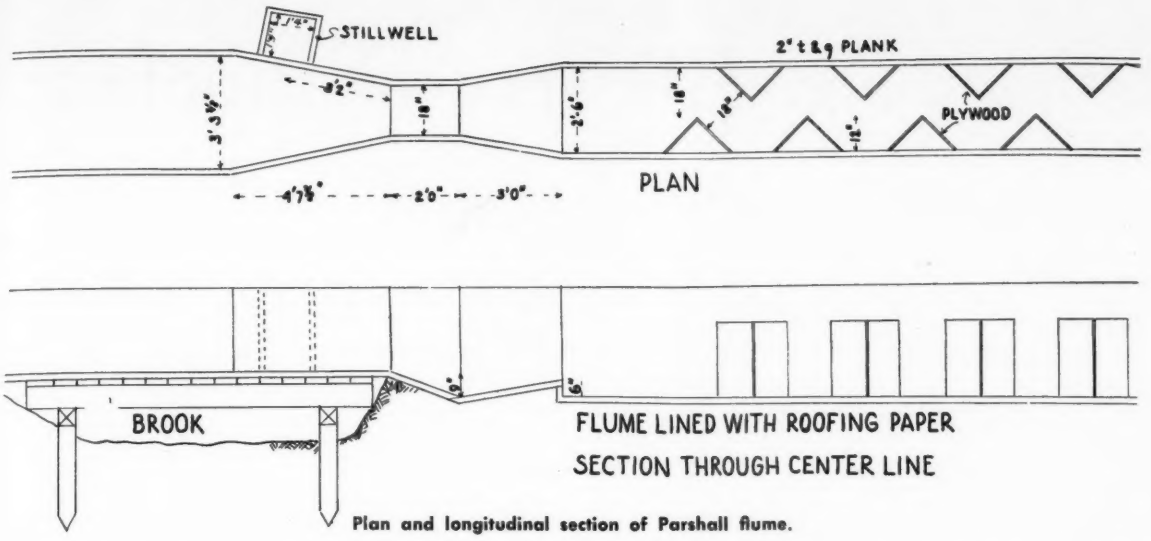
By the appointed date, the only structures fully completed were the grit and the screening chamber. The second diversion chamber, with its by-pass link to the first, was still in process. Accordingly it became necessary to insert a diversion manhole just above the screening chamber and a junction manhole on the lateral to the lagoon, with a pipe connection between the two, circling around the west PC. The lime machine, received just the day before, was placed over the second manhole.

In the meantime the wood flume terminal section of the lateral and the chlorine solution storage tank, together with its discharging device, were being rushed to completion. For the solution, an 8 x 8 x 4 reinforced concrete tank, on timber foundations and with a wooden roof, was provided. The flume just ahead of the dosing point was fitted with a wood-bar screen, while just below it was shaped to form a Parshall flume with an 18″ throat. A stillwell was provided at the 3rd point of the converging section to house a float device for indicating the flow. The section beyond the Parshall to the end was fitted with a series of vertical baffles, herringbone fashion, to promote mixing and absorption of oxygen. At the further end of the lagoon two 5 ft. wide wooden shallow flumes, or spillways, were built to carry the effluent across the separating embankment into the brook. These were protected with a boom to intercept the floating solids (for the most part grease), and in addition there was a screened baffle at the entrance. One spillway was set 2 in. higher than the other, so as to come into use only during periods of high flow. The lagoon varied from 5 to 9 ft. in depth with an area of roundly 6,000 s.f. This was larger than necessary for contact; fortunately so, as it has since proved to be well sized to serve as a settling basin for such flow as we have had to date.

As a vehicle for the chlorine, sodium hypochlorite (NaOC1) was chosen rather than the more usual calcium hypo, on account of its having a much lower freezing point—minus 10°F. The experience of the winter just past has fully vindicated the wisdom of this choice, as on several occasions temperatures lower than minus ten occurred but not once did the improvised dosing device fail to function smoothly. However, the stillwell did freeze once, breaking the glass float, repetition of which was avoided by covering with tar paper and placing a lantern within.

A ¾ in. piece of air-hose was provided as an outlet near the bottom at one corner of the solution tank. This was connected through a short piece of ¼″ rubber tubing slipped over a bit of glass tubing inserted in a rubber cork stoppering the air-hose into an adjacent brine jar supported by an iron ring from a stand and carrying an adjustable ¼ in. rod to pinch the rubber tubing, as the rate of discharge varied, against the glass float in the jar. This insured a constant pressure regardless of the level of the solution in the tank.

A variable discharge into the sewage was provided by carrying the discharge tubing on a board hinged at the end close to the jar outlet, and at the other end hung by two sash cords operating over pulleys, one suspending a counter-weight and the other going down to a wood float in the sewage stream. It was adjusted so that, for zero sewage flow, the outer end rose just high enough to shut off the solution feed into the jar, and conversely, for maximum sewage flow, fell to a level just below the bottom of the jar, in that position permitting an unpinched, or full flow. A 4 in. high submerged weir in the flume just below the point of dosing insured a depth of flow upstream sufficient to keep the float off the floor. The float itself was made of two short 2x4's on edge about 6 in. apart, battened at



Plan and longitudinal section of Parshall flume.

either end and carrying an axle midway, on which was strung the free end of a 2 in. strip 3 ft. long, hinged at the other end to the flume floor.

This chlorine-dosing device, while far from perfect, has nevertheless served to enable us, with a modicum of attention and only slight adjustments and minor repairs from time to time, to maintain a residual in the lagoon of between 4 and 5 ppm—the figure wanted by the State Health Authority.

The bleach solution is brought in 1300 gal. lots by tank truck from a point about 20 miles distant. It delivers approximately one lb. of available chlorine per gal., and while more expensive than the gas, there was seemingly no alternative under the circumstances.

The lime is received in 50 lb. bags, 30 days' supply at a time. It is fed dry and thus far there has been no difficulty from caking. A test recently taken by the plant's laboratory technician (among his first operations after getting the laboratory in order) showed a reduction of settleable solids of over 90% and a pH of 10 for the lagoon effluent. It is being fed at the rate of 75 lbs. per thousand population rather than on the basis of flow, roughly equivalent to 1000 lbs. per mg after correction for infiltration and wastage due to faulty plumbing.

In the stillwell at the Parshall flume is housed a float supporting an indicator reading against a scale graduated in accordance with the Parshall formula for an 18″ throat. The float itself is a glass globe identical to that used in the constant level jar, with the tit turned upward, upon which the indicator, a wood rod, rests, being coupled thereto with a piece of rubber tubing acting as a sleeve. The globe is enclosed in two brine jars with their bottoms removed, opposite ended with an intervening cement sleeve, to provide the requisite vertical distance for the range of flows anticipated (zero to 5 mgd). Readings are taken hourly and averaged to give the approximate daily flow.

That the combination of lime and bleach solution has also been yielding a bacteriologically satisfactory effluent has been shown by every test taken by agents of the health authority. I cite the results of one taken in mid-November:

	Bacteria pcc			*Col. Bacteria*				
	4 days	*24 hrs.-37°C*		*1M*	*1C*	*10*	*10*	*cm*
STAGE	*@ 20°C*	*Total*	*Red*				+	—
Raw Infl.....	240M	120M	7M	+	+	+	1	0
(1) Effluent	12	2	0			0	0	1
(2) Brook	800	2	0			0	0	1
(3) Pond	4200	12	0			0	0	5

(1) As discharged from flume, i.e., before settling.
(2) Just above the lagoon, i.e., ahead of the lagoon discharge.
(3) The pond about a mile below, or just before entering the river.

Treatment on the improvised basis above described began on October 8, 1942, and has so continued without change to this date. In the meantime there has been a change in the route to the lagoon. Flow was admitted to the screening chamber on Dec. 29, thence reaching the lateral to the lagoon via the by-pass subchamber of Dc-2. At the same time the lime machine, with its housing and adjacent lime storage house, was moved to MH 1-A, which is just above the screening chamber, where it is to remain indefinitely.

The screening chamber, as already described, is equipped on the one side with a conventional, manually operated bar screen (1″ spacing), and on the other with a 25 M Chicago Pump Co. "Comminutor," counterclockwise. Owing to lag in the electrical work and other conditions, the comminutor was not put into service until March 19, since which time it has been operating continuously, without trouble. On the 29th of March the lagoon was bailed out for the first time, a crane being used. The deposit of solids was found to be far less than anticipated and removal of any portion could have been postponed. The basin will be given a thorough cleaning when the next stage of partial treatment is reached, namely when sewage is admitted into one of the PC's and the sludge henceforth is drawn off to the other (sludge) lagoon, and the first lagoon becomes only a contact basin as originally intended. We are almost at that stage at this writing. Full use of the plant will probably follow within the next month.

Even after the full plant is in use, the provisions which have thus far served so well, including both lagoons and the arrangement for dosing with bleach, will be retained and maintained in serviceable condition, as a standby, in case trouble with the automatic chlorinator should develop or the volume of sewage increase at some future date (a possibility, even a probability at army posts in war time) beyond the rated capacity of the machine, and of the capacity to recirculate as planned. Then, instead of by-passing the excess, with under-chlorination, it will always be possible to shunt a due proportion, after primary clarification, to the lagoon, chlorinating en route with the bleach; also to lime again for the time being, if adjudged advisable, to accelerate and increase the settling out of solids in the PC's.

(Continued on page 52)

Methods and Efficiency of Disinfecting Jute Packing

Conclusions from experiments conducted by Army engineers, using chlorine, autoclaving, soaking in boiling water, and dry heat.

Despite flushing and cleaning and the application of relatively high dosages of chlorine, high bacterial counts and gas formers often persist in the water drawn from newly laid water mains. Such unsatisfactory samples are always a cause of worry and trouble since there is always the chance that actual contamination may be entering the water supply. In many cases repeated applications of chlorine are required before satisfactory water samples are obtained.

It has been quite generally recognized that much of this trouble may be due to the jute used in making the joints, since this normally shows a high bacterial life. Several methods have been used to disinfect such jute. In order to obtain information on the various methods a series of experiments were carried out in the Fourth Service Command Laboratory, U. S. Army, Lt.-Col. D. M. Kuhns, M. C., commanding, under the direction of Capt. J. E. Kiker, Sn. Corps, and similar tests were made independently by Capt. G. H. Eagle, Sn. Corps, at Fort Jackson, S. C.

Methods Tested.—The following methods of disinfection were tested:

1. Soaking in chlorine solution (5 min., 30 min., 1 h. and 12 hrs.)
   - (a) containing 50 ppm free chlorine
   - (b) " 100 " " "
   - (c) " 200 " " "

TABLE I. Results Obtained from Disinfection Tests, Fourth S. C. Laboratory

Untreated Packing	Coliform Organisms: A M.P.N. of rinse water	Coliform Organisms: A x5/wt. in gms M.P.N. per gm of packing	37° Bacterial Count: B Cols. per cc of rinse water	37° Bacterial Count: B x500/wt. in gms Colonies per gm of packing
Sample No. 1a	2400/	12,000/	7,780	3,890,000
" No. 1b	2400/	12,000/	5,156	2,578,000
" No. 1c	2400/	12,000/	6,690	3,495,000
Average	2400/	12,000/	6,632	3,321,000
Treated Packing				
2. Soaking in chlorine solution				
a. 5 min. in 50 ppm	2.2	11.0	650	325,000
b. 30 " " "	2.2	11.0	420	210,000
c. 1 hr. " " "	15.0	75.0	380	190,000
d. 12 hr. " " "	21.0	105.0	950	475,000
e. 5 min. in 100 ppm	0.0	0	185	92,500
f. 30 " " "	2.2	11.0	230	115,000
g. 1 hr. " " "	6.8	440	190	95,000
h. 12 hr. " " "	0.0	0	400	200,000
i. 5 min. in 200 ppm	0.0	0	95	47,500
j. 30 " " "	0.0	0	190	95,000
k. 1 hr. " " "	0.0	0	120	60,000
l. 12 hr. " " "	2.2	11.0	540	270,000
3. Autoclaving or subjecting to live steam under pressure				
a. 20 minutes @ 121°C & 15# pressure	0.0	0	0	0
b. 30 minutes @ 121°C & 15# pressure	0.0	0	5	2,500
4. Soaking in boiling water				
a. one minute	0.0	0	40	20,000
b. 5 minutes	0.0	0	20	10,000
c. 10 minutes	0.0	0	10	5,000
d. 30 minutes	0.0	0	20	10,000
5. Subjecting to dry heat				
a. 30 minutes @ 120°C (248°F)	240.0	1200	1400	700,000
b. 60 minutes @ 120°C	96.0	480	100	50,000
c. 30 minutes @ 150°C (302°F)	2.2	11.0	80	40,000
d. 60 minutes @ 150°C	0.0	0	60	30,000

Table II. Results of Tests at Fort Jackson, S. C.

Jute Sample Placed in	Method of Sterilization	Effect	Bacterial Analysis
1. Metal container	Oven ½ hr. 180°C.	Fibers dry and brittle	No attempt made
2. Paper container	Oven ½ hr. 180°C.	Fibers dry and brittle	No attempt made
3. Water	Boiled ½ hr. in water	Fibers swelled, oil and color dissolved	No attempt made
4. Metal container	Autoclaved ½ hr 250°F.	No noticeable change	No bacterial growth
5. Paper container	Autoclaved ½ hr 250°F.	No noticeable change	No bacterial growth
6. ---	Unsterilized	---	Immeasurable

2. Autoclaving or subjecting to live steam under pressure
   - (a) One minute
   - (b) five minutes
   - (c) ten minutes
   - (d) thirty minutes
3. Soaking in boiling water, for
   - (a) One minute
   - (b) five minutes
   - (c) ten minutes
   - (d) thirty minutes
4. Subjecting to dry heat.

Procedure Used. Untreated Packing.—Cut packing in five strips about two inches long and weigh each strip. Grind each strip in 500 cc of water and examine 0.1, 1 and 10 cc portions as in regular bacteriological examinations. Report results, including 37° count. (M.P.N. x 5/ weight in grams = most probable number of coliform organisms per gram of untreated packing.)

Treated Packing.—Cut packing in strips about two inches long and weigh each strip. Treat the strips as indicated in table. After treatment, grind each strip in 500 cc of water and examine as in regular bacteriological examinations. Report results as for untreated packing. M.P.N. and 37° count to be determined on each strip and the results recorded as shown in table.

The results of these tests are given in the accompanying tables, Table I giving those obtained at the Fourth Service Command Laboratory, and Table II those at Fort Jackson, S. C. The former gives the bacteriological results, the latter the physical effect. Coliform organisms were found at the rate of more than 12,000 per gm of the packing. These were reduced 99.- to 100% by soaking in chlorine; 100% by either autoclaving or soaking in boiling water; 90% by 120° C dry heat, 100% by 150° dry heat. But dry heat rendered the fibres dry and brittle, and with boiling they swelled and the oil dissolved. With autoclaving there was no noticeable change.

(Continued on page 60)

Courtesy Wood Preserving News

Approaches consist of 17-ft. trestle spans of conventional design. Floor spans are deck trusses to utilize small size timbers.

Army Builds Creosoted Timber Bridges

Details of construction of fifteen bridges built in the development of a large southern army cantonment, using a minimum of steel.

FIFTEEN creosoted timber highway bridges totaling over one-half mile in length were constructed in the development of a large southern Army cantonment. Pre-framed all-timber trusses 60 ft. long with Teco ring connectors at all joints were used for channel spans where wider unrestricted waterways were desirable than were practicable in trestle construction. Standard timber trestles of the conventional design were used for approach and other short spans. All bridges have a 24-ft. clear vehicular roadway and are designed for the standard H-15 truck train loading. Those in areas of heavy pedestrian traffic have an 8-ft. sidewalk on either side of the vehicular roadway.

Where sidewalks are provided, additional trusses are set outside the roadway truss to support the outer edge of the walks.

The longest bridge on the project is 580 ft. in length and consists of two 60-ft. truss spans, two 17-ft. trestle approach spans on the east, and twenty-five 17-ft. approach spans on the west. An 8-ft. sidewalk is carried on either side of this bridge.

The creosoted timber trusses are of the pony type with a height of 7½ ft. between chord centers. The deck surface is carried at mid-truss height to facilitate connection between the verticals of the main trusses and the floor beams, which are also trusses framed from ordinary sizes of structural plank. The vehicular roadway in all cases is supported by two trusses 28 ft. center to center. Where sidewalks are provided, an additional truss of similar span, height and panel length, but of lighter design, is erected 9 ft. 8 in. outside the roadway truss on each side of the bridge to support the outer edge of the walk. Eleven separate trusses were required for each span—2 main roadway trusses, 2 sidewalk trusses, and 7 floor beam trusses.

All framing and boring were done at the wood preserving plant before treatment. To assure a uniform fitting, the truss members were completely framed, bored, and assembled, then taken apart and grooved for split ring connectors. Members were marked in accordance with the framing diagram for ready identification for field assembly.

(Continued on page 60)

RECOMMENDED LUBRICANTS FOR DORR EQUIPMENT

NO. 552

RECOMMENDED BY	GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5	GROUP 6	GROUP 7	GROUP 8	GROUP 9
SOCONY-VACUUM OIL COMPANY	S Gargoyle Cylinder Oil 600 W W Voco Engine Oil No. 1	Gargoyle DTE Oil Extra Heavy Gargoyle Arctic Oil C	Gargoyle DTE Oil Light Arctic Oil C	Gargoyle Grease CN Medium Gargoyle Grease CN Soft	Gargoyle Grease AA No. 2	Gargoyle Grease AA No. 2	Gargoyle Grease AA No. 2	Gargoyle Grease Graphited No. 3	Voco Engine Oil No. 1
STANDARD OIL COMPANY OF INDIANA	S Standard Worm Gear Oil W Nonpareil W	Stanoil No. 95 Stanoil No. 35	Stanorust No. 00	Calumet Viscous Lubricant No.8X Calumet Viscous Lubricant No. 5X	Superla Grease No. 42	Superla Grease No. 2X	No. 1 Arctic Compound	Std. Automotive Graphite Grease	Standard Marine Engine Oil No. 1
TEXAS COMPANY	S Texaco 650 T Cylinder Oil W Texaco Ursa Oil	Texaco Regal Oil E Texaco Regal Oil C	Texaco Home Lubricant	Texaco Crater No. 0 Texaco Crater B	Texaco Star Grease No. 1	Texaco Starfak Grease No. 2	Texaco Star Grease No. 1	Texaco Texmill Grease No. 2	Dolphin Marine Engine Oil
GULF OIL CORPORATION	S Senate Cylinder Oil A W Merit Oil B	Harmony Oil E Paramount Oil A	Harmony Oil A	Lubecote No. 1	Gulf High Pressure Grease	Gulf H.M. Grease	Gulf High Pressure Grease	Graphite Grease No. 1	Merit Oil B
SINCLAIR REFINING COMPANY	S Modoc Cylinder Oil Light W Rubilene Oil Extra Heavy	Rubilene Oil Medium Heavy Gascon Oil B	No. 117 Slushing Oil	Shamrock Lubricant C Shamrock Lubricant A	Opaline Pressure System Grease	Bearing Grease AF	Shamrock Lubricant A	No. 221 Graphite Air Brake Comp.	No. 147 Air Drill Lubricant
ATLANTIC REFINING COMPANY	S Capitol Cylinder Oil W Atlantic Hfs Oil No. 10	Atlantic Hfs Oil No. 10 Polar Oil Heavy	Stainless Spindle Oil	Atlantic Lubricant No. 27 Atlantic Lubricant No. 22	Atlantic Lubricant No. 100	Atlantic Lubricant No. 62	Atlantic Lubricant No. 56	Atlantic Lubricant No. 112	Atlantic Marine Engine Oil No. 1
PURE OIL COMPANY	S Poco Purelube BB W Poco Purelube EE	Klondyke Heavy Puroco Ct Heavy Medium	Klondyke Medium	Poco Compound 100 Poco Compound 50	Poco Bearing Grease No. 2	Poco Bearing Grease No. 2	Poco Water Proof Grease	Poco Graphite Grease No. 2	Puro-Marine Oil—Extra Heavy
STANDARD OIL COMPANY OF CALIFORNIA	S RPM Gear Lubricant Sae 140 W RPM Gear Lubricant Sae 80	RPM Gear Lubricant Sae 80 Calol Turbine Oil 15	Calol Edger Arbor Oil	Calol 304 Gear Grease	Calol W. P. Grease	Calol W.P. Grease	Calol W.P. Grease	Calol Dredger Lubricant	Calol Marine Oil 27X
SHELL OIL COMPANY	S Lead-O-Lube 4½ (E.P. 140) W Lead-O-Lube 3½ (E.P. 90)	Albus Oil 69 Latus Oil 41	Turbo Oil 27 Latus Oil 27	Cardium Compound XX	Service Grease No. 2	E.X.L. Grease No. 2	Service Grease No. 2	Graphite Grease No. 3	Carnea Oil 69K
STANDARD OIL COMPANY OF N. J., PENN., AND LA.	S W Pen-O-Led E.P. 3	Pen-O-Led E.P. 3 Pen-O-Led E.P. 1	Rust-Ban 337	Surett Compound 800 Surett Compound 310	Cazar Lubricant 1	Andok Lubricant M-275	Cazar Lubricant 1	Van Nakta 20	Arox 60
CONTINENTAL OIL COMPANY	S Conoco Trans. Oil Sae 140 W Ice Machine Oil Special Heavy	Conoco Dectol Heavy Ice Machine Oil Special-Heavy	Conoco C Redind Light Ice Machine Oil Medium Heavy	Conoco Coglube No. 7 Conoco Goglube No. 5	Conoco Oconoc No. 20	Conoco Rotalube No. 33	Conoco Oconoc No. 20	Conoco Graphlube No. 21	Conoco C Redind Heavy

Lubrication of Machinery in Water and Sewage Treatment Plants

Suggestions by lubricant and machinery manufacturers for the selection of oil and grease lubricants for various parts of such machinery. How to use them will be described next month.

THE general basic principles of use of lubricants is the same for all machinery, but details of their application vary with the kinds of machinery and the conditions under which they operate. As compared to road construction machinery, discussed last month, equipment used in water and sewage treatment plants is generally of low horsepower; it is operated by electric motors rather than by internal combustion engines; it is stationary; it is not subject to deposits of mud, dust, cement, rain and hard usage.

But much of it operates under water, which may be more or less acid or alkaline; most of it in the continuous presence of moisture; and it may be located where temperatures are below freezing for weeks at a time. In such machinery will be found bearings, gears, chains, and sliding surfaces which need lubrication.

Selection of Lubricants

Manufacturers provide a considerable variety of lubricants, each considered most suitable for some particular lubrication point; where subject to wide variations of temperature, two or more grades are usually offered for each point. For example, Fiske Brothers Refining Co. offers Lubriplate Nos. 1 and 2 for oil-type high speed plain bearings; Nos. 2 and 3 for high-speed chain drives, totally enclosed; Nos. 3 and 4 for medium and low speed plain bearings, oil type; for oil type ball and roller bearings; for high speed gears, totally enclosed (speed reducers); for medium and slow speed chain drives, totally enclosed; for force speed or oil circulating systems; and for air compressors and vacuum pumps. No. 4 is used for open or partially enclosed chain drives. For medium and slow speed gears, totally enclosed, Nos. 20 and 25 are used. Grease-type lubricants are furnished as follows: For plain bearings, Nos. 107 or 110 for temperatures below 200°F., Nos. 70 or 315 for higher temperatures; for ball and roller bearings, "ball bearing" grease, or Nos. 107 or 110 with water conditions; Nos. 130 A or 130 AA for exposed type gears; Nos. 107 or 130 AA for chain conveyors; and Nos. 105 or 107 for force feed lubrication.

Dorr Co. has classified parts of its equipment under 9 heads, and has prepared a table recommending, for each group, the lubricants offered by 11 different manufacturers. This table is reproduced herewith. The 9 groups are described as follows:

Group 1: Enclosed bath lubricated worm gears and combinations including worm gears. (Type A and W drive heads. Clari-flocculator two-speed drive head, etc.)

Group 2. Enclosed bath lubricated gears and combinations *not* including worm gears. (Type S, SU, SS, SSX Clarifier and Thickener center mechanisms, Agitator spur gear drive heads, enclosed chain guards, pump gear cases, etc.)

Group 3. Distributor turntables.

Group 4. Open gears. (Flocculator bevel gears and chains in dry-well.)

Group 5. Plain bearings lubricated by grease gun.

Group 6. Commercial ball and roller bearings.

Group. 7. Underwater metallic bearings. (Flocculator paddle shaft, Digester mixer steady bearing.)

Group 8. Underwater non-metallic bearings. (Flocculator paddle shaft and chains in water.)

Group 9. Sludge pump plunger.

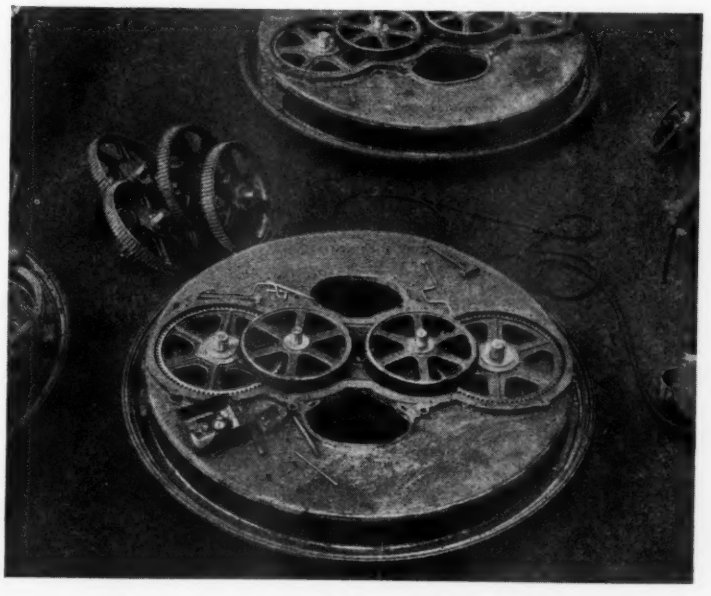
S refers to those for summer use, W for winter use.

Oils in Group 1 should be changed to winter grade when prevailing temperatures go below 30°F. Summer lubricants for other groups may be used safely all the year round in districts where temperatures do not drop to 0°F. Where only one product is shown, it is suitable for all climates. Lubricants should be renewed in any case as recommended in the operating instructions.

For Universal Gear Co. units used with Dorr equipment, there are recommended: for worm gears, Gargoyle DTE oil BB (SAE 50), or Stanoil No. 150 (SAE 50), or Havoline motor oil SAE 50, or Rubilene extra heavy SAE 50. For herringbone gears, Gargoyle DTE oil, extra heavy (SAE 40) for temperatures below 50°, and BB (SAE 50) for above 50°; or Stanoil No. 75 (SAE 40) below 50°, No. 150 (SAE 50) for above 50°; or Havoline motor oil, SAE 40 for below 50° and SAE 50 for above 50°; or Rubilene heavy (SAE 40) for below 50° and extra heavy (SAE 50) for above 50°.

The Chicago Pump Co. recommends, for use in its "Comminutors," "good waterproof, mineral-base, bearing grease, such as Sinclair C, Texaco chassis lubricant, or Shell semi-fluid pressure lubricant," using the same

(Continued on page 54)



Shop assembly of a balanced drive for a SU Dorr Clarifier; group 2 in lubricant table.

Utilizing Siphon

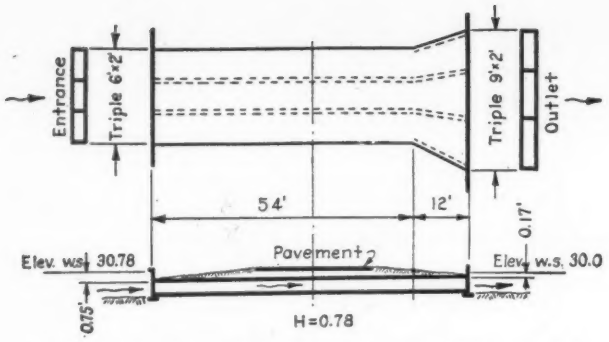


Fig. 5—Layout of experimental Vallejo Creek triple flare-siphon box culvert.

GENERALLY, a siphon is any conduit within which the absolute pressure falls below atmospheric at some point or at some stage. The term "inverted siphon" has unfortunately become established in civil engineering literature to designate a conduit which lies below the hydraulic gradient, which is in no sense a siphon at all. The American Society of Civil Engineers in 1935 recommended that these be called "sag pipes." A culvert so constructed would then be called a "sag culvert."

Sag culverts are used extensively in California to pass irrigation canals under highways, usually providing a constricted section under a narrow roadbed, so that the hydraulic gradient is much steeper than for the canal as a whole. If the culvert is extended because of widening the roadbed, the friction in the extension will increase canal stage at the entrance or reduce its capacity. This can be lessened by using, for the extension, smooth-bore conduit with a section 25 to 50% larger than the existing section. A standard culvert may become a sag culvert by general aggradation of the stream bed. Deposits may collect in these and reduce their capacity, and the cost of cleaning them become a serious maintenance item. Stagnation of water standing in sag culverts may be objectionable in many ways, and they should generally be avoided.

On the other hand, true siphons may be used for culverts to advantage in many places. In order to encourage development and design of siphon culverts and point out practical advantages and adaptations, a committee of the California Division of Highways has prepared a joint departmental review of culvert practice, being of the opinion that the principles involved will be applied frequently if the advantages and techniques are compiled for designers. This committee is composed of Clarence F. Woodin, assistant maintenance engineer, Robert L. Thomas, assistant engineer, surveys and plans, G. A. Tilton, Jr., assistant construction engineer, and R. Robinson Rowe, assistant engineer, bridge department. This article is slightly condensed from an abstract of the review prepared by the two last named and appearing in "California Highways and Public Works."

Siphon Culverts

Contrary to general belief, a culvert of constant section on a uniform gradient may siphon, as with a submerged entrance and either free or drowned outlet (Fig. 1-A and B), and the discharge thus exceed that calculated. It is not safe to count on this, however; for as shown by the illustrations, if a vacuum forms in a standard culvert with a uniform gradient, the vacuum head must be a maximum at a culvert end, and the disturbance caused by drift passing that end would permit the admission of air to break or reduce the prime.

If a standard culvert siphons because of a downbroken grade (Fig. 1-C), the vacuum head is a maximum at the break in grade; once primed, this type

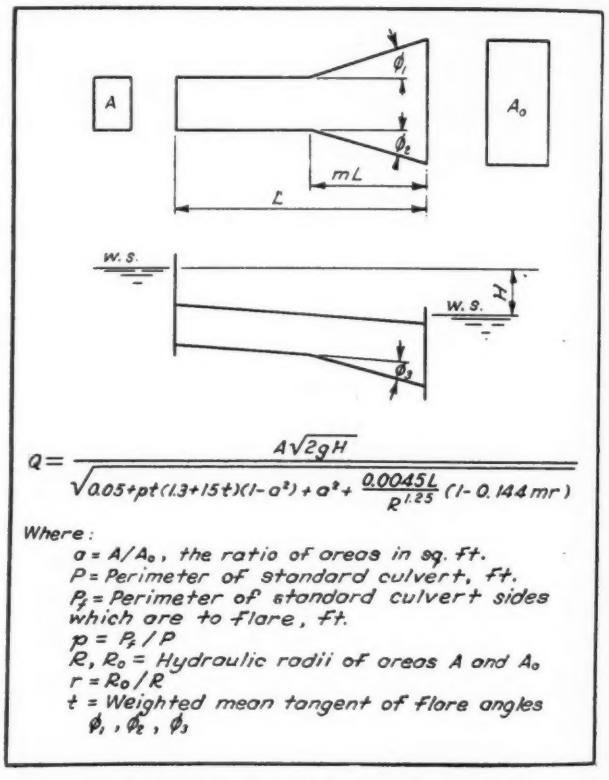


Fig. 3—Discharge formula for flare-siphon culvert.

will continue to discharge as if the grade were uniform between end flow lines. The hydraulics of such a culvert are illustrated by Fig. 2. The stage-discharge curve is the broken line OABDE for rising stage and EDCBAO for falling stage. While rising between B and D, the siphon may be partly or wholly primed by air entrainment, reducing the stage relation to some point in the area BDCB. Limiting positions of energy and hydraulic grade lines for one discharge are shown in profile at the right.

Advantage of this design lies in the saving of excavation, and opportunity afforded to adjust the location and grade to insure adequate foundation and outlet conditions. Frequent floods will be carried without increase in stage (below B). Infrequent floods will have a higher stage on the rise but a normal stage on the fall. Peak stage of rare floods (above D) will be unaffected. Since floods are usually quick to

...inciples in Culvert Design

Where true siphons can be used to advantage for culverts and how to design them. Flared siphons believed by California engineers to be an ideal solution for many drainage problems.

rise and slow to fall, the net effect of the grade break is small.

Flared-siphon Culvert

The flared-siphon (Fig. 1-D) utilizes the principle of an expanding tube (Venturi) to salvage a large part of the water's kinetic energy. Ordinarily, the sudden enlargement at the outlet wastes 95 per cent or more of the velocity head. This waste is desirable for steep channels, but for cross drainage in broad valleys, the wasted energy is reflected in damaging stages above the culvert entrance.

If the flare is built to diverge on eased curves, little energy will be lost in the transition. The longer the flare and the larger the outlet, the greater the salvage of energy. Thus, if outlet area is doubled, the outfall velocity is halved and kinetic energy wasted at outfall will be quartered. In theory, it is possible to salvage 90, or even 99, per cent of the kinetic energy, but at a large structure cost.

In practice, the flare can be built with flat instead of curved walls and with outlet from 1.5 to 2.0 times the standard section in area, so as to salvage 60 to 70 per cent of the kinetic energy. For any particular site, the most economical flare dimensions will depend upon local factors—requiring hydraulic computations. For reference, this most economical design is termed the "ideal flared-siphon."

Tests made by the University of Iowa showed the hydraulic advantages of the flared siphon—quantitatively for particular designs and generally for similar designs. For example, the report stated that capacity of a box culvert 36 feet long could be increased about 60 per cent by flaring the downstream 10 or 12 feet so as to double the outlet area. For the general case, the committee has prepared a formula (Fig. 3) agreeable to all test data and extended by theoretical considerations. This formula is suitable for design, for the complicated expressions become quite simple when some proportions are determined arbitrarily.

Figure 4 is introduced to illustrate the methods of computation. Suppose the 10-year flood had determined the size of standard section as a 2 x 2 box and it was proposed to increase the capacity by flaring to a 4 x 2 section in the last 6 feet of a total length of 30 feet. Then $A = 2 \times 2 = 4$; $P = 2 + 2 + 2 + 2 = 8$; $R = 4/8 = 0.5$; $L = 30$; as in usual formulae.

At the outlet, the hydraulic radius is 0.667, so "r" $= 0.667/0.5 = 1.33$. Two sides of the box will be flared, so $P' = 2 + 2 = 4 +$ hence $p = P'/P = 4/8 = 0.5$. Also "a" is the ratio of the areas,

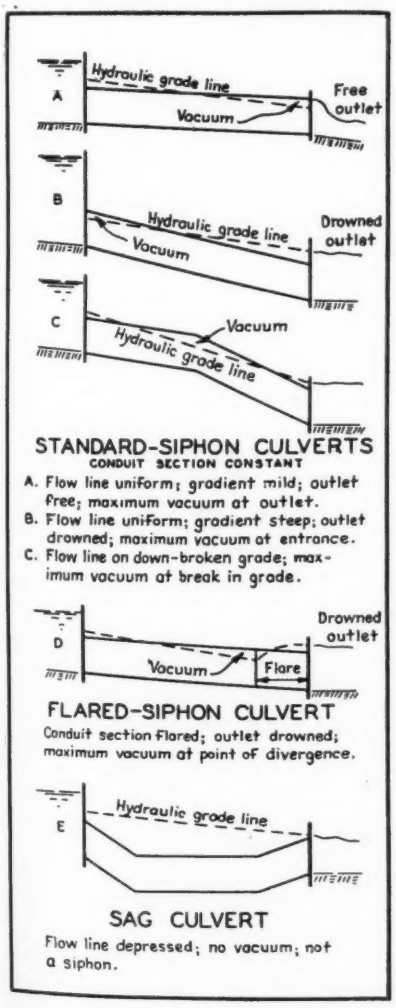
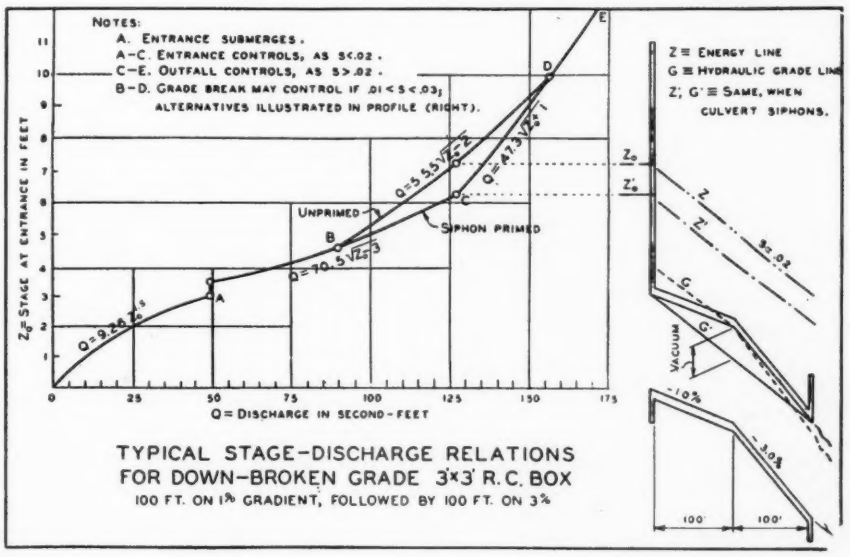


Fig. 1—Left. Classification of siphons and sag culverts.

Fig. 2—Below. Hydraulic study of siphoning (Class C) in standard culvert on down-broken grade.


NOTES:
A. ENTRANCE SUBMERGES.
A-C. ENTRANCE CONTROLS, AS S<.02.
C-E. OUTFALL CONTROLS, AS S>.02.
B-D. GRADE BREAK MAY CONTROL IF .01 < S < .03; ALTERNATIVES ILLUSTRATED IN PROFILE (RIGHT).
Z = ENERGY LINE
G = HYDRAULIC GRADE LINE
Z', G' = SAME, WHEN CULVERT SIPHONS.
UNPRIMED
SIPHON PRIMED
VACUUM
Q = DISCHARGE IN SECOND-FEET
TYPICAL STAGE-DISCHARGE RELATIONS FOR DOWN-BROKEN GRADE 3'×3' R.C. BOX
100 FT. ON 1% GRADIENT, FOLLOWED BY 100 FT. ON 3%

2x2/4x2 = 0.5; and "m" is the proportion of length to be flared = 6/30 = 0.2.

Flare Formula Factors

The flare angle may be complicated for skew culverts or boxes flared on 3 or 4 sides. The top slab should never be flared, for that raises the stage (and discharge) for priming the siphon. Rarely will there be advantage in flaring the bottom slab; if a lower outfall flow line is practical, capacity can be obtained more economically by lowering the flow line to a uniform gradient. In the example, each side wall flares one foot in six, so "t" = 0.167.

Substituting these simple values in the formula, the expression reduces to $Q = 34.8 \sqrt{H}$, where H is the difference in stage between forebay and tailwater. Without the flare, the relation would be $Q = 27.4 \sqrt{H}$. Assuming a typical tailwater stage, two stage discharge curves were drawn for comparison of the flared siphon with the uniform section.

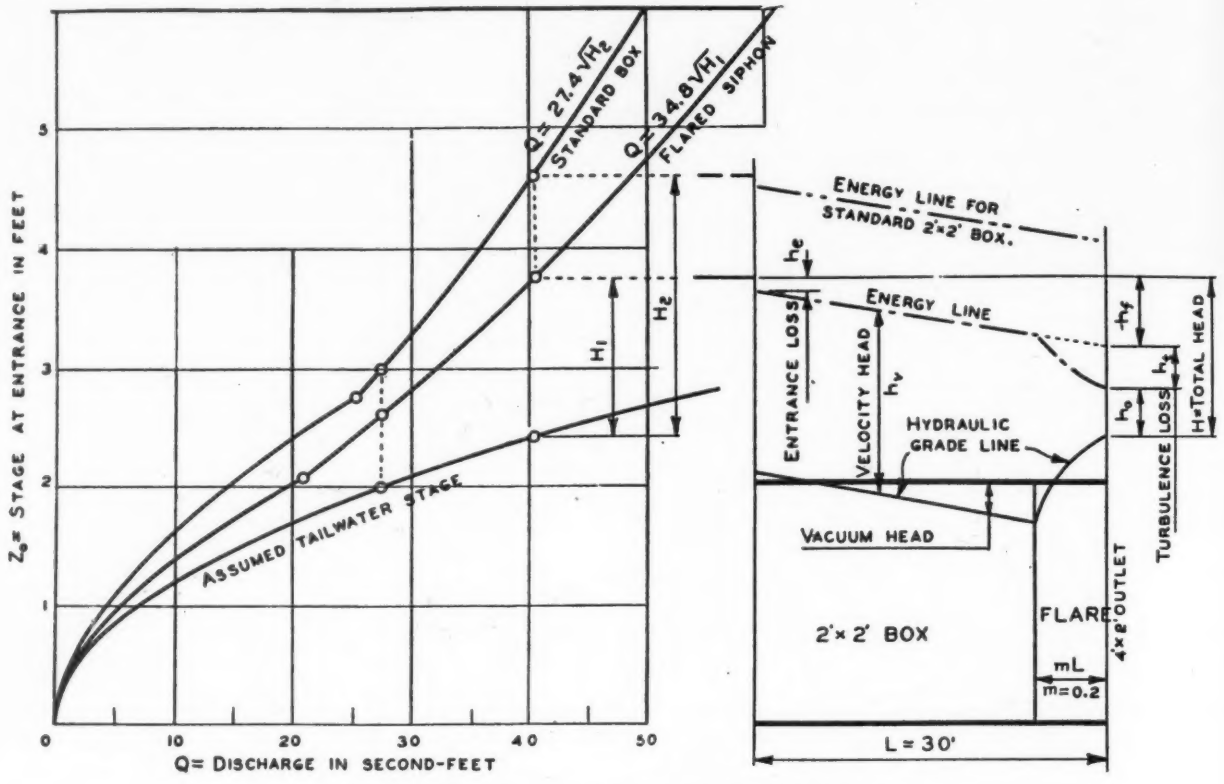


Fig. 4—Hydraulic comparison of flare-siphon with standard culvert.

At the right of Figure 4 are profiles of the hydraulic grade line and energy line, on which are shown the relative losses in the culvert. The total head "H" has 4 components. The flare design has little or no effect on entrance and friction components. The turbulence loss in the flare can be reduced by lengthening or curving that portion and the loss at outlet "h_o" depends on area of outlet section. These losses should be visualized by the designer, to avoid disproportionate loss of energy or increase in construction cost.

In any case, the ideal flare-siphon culvert must be designed by cut and try, at least until a wider variety of governing factors have been analyzed. As a guide, the area ratio "a" will vary from 1.5 for moderate velocities to 2.0 for high velocities. The flare-length ratio "m" will vary from 0.1 for long culverts under moderate fills to 0.3 for short culverts under no fill. The flare angle tangent "t" should not exceed 0.2 for moderate velocities or 0.1 for high velocities, or the diverging jet will not wet the outer walls (causing a gurgling turbulence as prime is intermittently lost).

Flared Siphon Applications

The flared-siphon culvert is an ideal solution for many drainage problems. The first installation in California is shown diagrammatically in Fig. 5. At this site, an existing culvert had proved inadequate after a rural area had been developed into a residential suburb, crowding a stream of the meadow-overflow type. Economy demanded full capacity without exceeding the damage-incidence stage. The flared siphon proved much cheaper than standard culverts of the same capacity at limiting stage.

The design is experimental in that the flare was applied to a triple box. We hope to observe whether the outer boxes are as efficient as the central box. The flared siphon should be considered in all widening plans in the broad valley areas, because existing culverts can be so extended as to increase their capacities. Submergence of outlet is a necessary condition, of course; if submergence is not natural, it can be obtained by building a sill or weir on the apron. There is great promise in this design, as otherwise the existing culvert may have to be reconstructed to avoid overtopping. The flare extension can be added without interruption to traffic.

Committee Recommendations

Summarizing the discussion of sag culverts and siphons, the Committee recommends generally that:

1. Use of sag culverts should be restricted to sites where silt load is negligible and stagnation can not be objected to.
2. Sag culverts carrying canal water should not be

(Continued on page 54)

Low water at Club Lake in September. View of floating dock at pumping station.

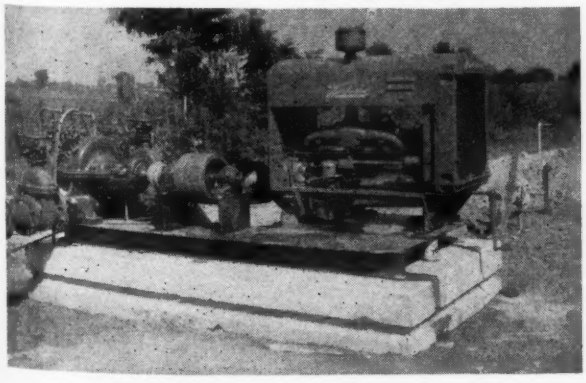
Obtaining Water from Government Lake During a Drought

By CLIFFORD FORE

Supt. of Water and Sewage Treatment, Carbondale, Ill.

Shortage of water supply solved temporarily by laying a surface pipe line to a near-by lake; permanently by connecting with a lake owned by the Federal government.

UNTIL recently the city of Carbondale, Ill., obtained its water supply from a reservoir that is dependent upon rainfall entirely. A drought started in 1939, and April 23 of that year was the last time water discharged over the spillway; from which date until the reservoir was dry in 1941 the amount in storage continued to drop, even though we did catch some in the spring of 1940.



Pumping unit on Crab Orchard line.

On Oct. 31, 1939, the reservoir contained 221.8 m.g., and fell to 142.7 in January, 1940; then increased to 316.2 in May, and continued to fall to 3.0 m.g. by Sept. 30, 1941.

In 1932 the city had been faced with a possible water shortage, and secured a lease on a club lake ¼ mile north of this reservoir. When rains failed to come in the spring of 1941, and with only 30 mil. gal. in storage, we started laying a 6″ line on the surface to the club lake, which line was connected to our 16″ gravity supply. On June 14 we began pumping from this lake, removing 57 mil. gal., which lowered it to a very low stage.

When it became apparent that this supply would not last, even with rigid restrictions on usage, a reputable well-drilling company was called in for a survey. (Prior to 1926, when the city built the reservoir and filtration plant, water had been supplied from wells.) This company, after a thorough check, could only recommend a connection to the Government-owned Crab Orchard Lake, located 3½ miles east of the city, as a sure source of supply. Communications by letter and wire with the Department of Agriculture produced little result, and finally Mayor Johnson made a trip

Low water in city reservoir in July.

to Washington and convinced Secretary Wickard of our need and the Department agreed to sell us water from this lake at 2¢ per 1000 gal. plus $100 a year for the use of the intake.

A direct tax bond issue to finance the project was voted in July by a 3-1 majority. While waiting for the passage of the bond issue, the Mayor and Council called for bids on pipe, excavation, and construction work, and by the time the issue was passed all necessary contracts and land easements had been completed and work began early in August.

Fortunately, when the engineers designed the flood gates at the Government Lake dam, provisions were made for a connection, as they felt sure that some city or industry might want such connection in the future. Therefore, we were able to connect directly to the lake without building an intake. We used flanged C. I. pipe through the flood tunnel under the dam to where the meter was installed, from which point all joints were leaded. For a distance of approximately one mile the water flows by gravity through a 14″ C. I. pipe to the pump station, from which it is forced through a 12″ C. I. pipe into our gravity line near the filtration plant.

Probably the most difficult construction problem was crossing Crab Orchard creek just west of the pump station. As there was very little flow at that time, the creek channel was dammed and a corrugated pipe carried the flow over the excavation while the pipe was being laid, joints leaded, and concrete poured around them for support.

On each high point between the lake and pump station an automatic air relief valve was installed to rid the line of air. As these cost $20 each, we decided to use a corporation cock on each crest beyond the pump, which will, of course, have to be opened by hand each time the line is used after an idle period.

The pump, a Dayton-Dowd double-suction driven by a 6-cylinder Waukesha gasoline motor, is capable of pumping 2 m.g.d. This exceeds our demand and will allow for future increase in consumption. We began pumping from Crab Orchard Lake on Oct. 6, 1941, and pumped for 25 days, and again for 8 days in December, a total of 33 days in all. The cost of pumping from this lake was 4¢ per 1000 gal., including cost of water from Government, labor, fuel, etc.; increasing our production cost from 9¢ to 13¢ per 1000.

In mid-October, after we were certain of the supply from Lake Crab Orchard, our reservoir was drained, all fish were removed and the abundant crop of weeds were cut and hauled off or burned. As soon as enough water could be caught in our reservoir again, we returned to this supply, and have continued to use it since, to cut down the cost of production. A survey of the reservoir when it was dry, made by the State Water Survey, showed a decrease in storage capacity of 9.2% caused by silt.

Treatment of Lake Crab Orchard water was not much different from that of our own supply, except for its very low turbidity and high algae count. At that time Coelosphaerium was so abundant that the water near the intake had an appearance of "green paint," but we were able to control the tastes and odors produced by using large alum dosage and carbon. Citizens were so glad to have all the water they wanted again that no one thought of reporting a taste if it was noticed.

(Continued on page 52)

Mueller tapping machine making a 12 in. cut in a 16 in. line.

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* Back in the old days, second-rate Roman sculptors who made unsightly nicks in the marble would secretly patch up the flaws with a mixture of wax and marble dust. These patches would drop out later on and honest artists suffered so much that they began labelling their handiwork "Sine Cera" (i.e. "Without Wax"); from this we derive our word "sincere" meaning honest, genuine, real.

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Hydraulics Simplified

(Continued from page 12)

one acre totals approximately 1 cfs. If 50% runs off, the cu. ft. of runoff will be 0.5 times the rainfall rate times the drainage area.

1. Heads and Pressures.—(a). The pressure of water in a pipe or tank is a factor of the weight of the water. As already stated, a cubic foot of water weighs 62.4 pounds. Assuming a cube of water, 1 foot on a side, the weight of the water pressing on the square foot of bottom area is 62.4 lbs. Since there are 144 sq. ins. in a sq. ft., the pressure per sq. inch is 62.4 ÷ 144 = 0.433 lbs. The pressure of water against any surface is normal, that is, perpendicular, to the surface, and is of equal intensity in all directions. The intensity or amount of pressure is directly proportional to the depth of submergence or depth of water.

Therefore, the pressure per sq. in. due to each foot of head or depth of water is 0.433 pounds. For 60 ft. of head, the equivalent pressure is 60 x 0.433 = 26 pounds; for 100 feet it is 100 x 0.433 = 43.3 pounds. Conversely, a pressure of 50 lbs. indicates a head of 50 ÷ 0.433 = 115.4 ft.; a pressure of 70 lbs. indicates a head of approximately 161.5 ft.

Therefore to find pressure in pounds when the head is known, multiply the head by 0.433; to find the head in feet when the pressure is known, divide by 0.433 or multiply by 2.3.

(b). The suction lift of pumps is a function of atmospheric pressure. The atmosphere presses down on the earth surface with a weight, which at sea level amounts to 14.7 lbs. per sq. inch. This weight or pressure is called an atmosphere. A familiar demonstration of atmospheric pressure is a suction pump. From par. 7a above, it will be seen that, at sea level, the 14.7 lbs. per sq. in. pressure equals 14.7 ÷ 0.433 = 33.9 feet of head of water. This is the theoretical limit of lift of suction pumps, but actually the practical lift is about 26 or 28 feet, due to friction losses, air bubbles in water, air leaks and similar factors. Also, as the elevation above sea level increases, there is a lesser weight of air and consequently a lesser suction lift.

A mercury column is often used to measure atmospheric pressure, and because mercury is much heavier than water, the height of mercury column is less. A mercury tube is therefore often used to measure vacuum. Atmospheric pressure of 14.7 lbs. equals 33.9 feet of water, but only 29.92 ins. of mercury. The influence of elevation above sea level is shown in the following table:

Elevation Above Sea Level	*Atmospheric Pressure*	*Equivalent Hght. of Water*	*Elevation Above Sea Level*	*Atmospheric Pressure*	*Equivalent Hght. of Water*
0 (Sea level)	14.7	33.9	3000	13.15	30.34
1000	14.16	32.65	4000	12.68	29.24
2000	13.64	31.47	5000	12.22	28.18

Thus, it will be seen that for each 1000 feet increase in elevation, the theoretical suction lift is decreased about 1.2 feet.

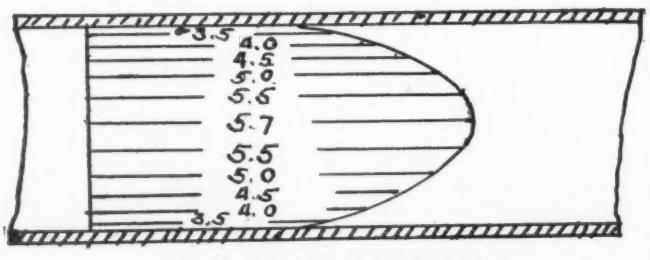


Fig. 1b—Curve of velocity in a pipe.

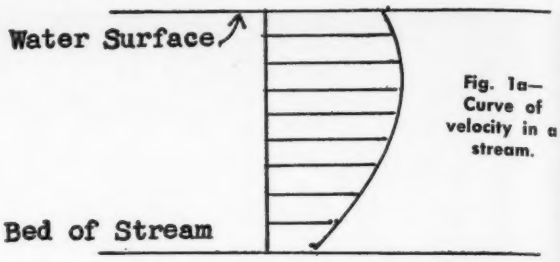


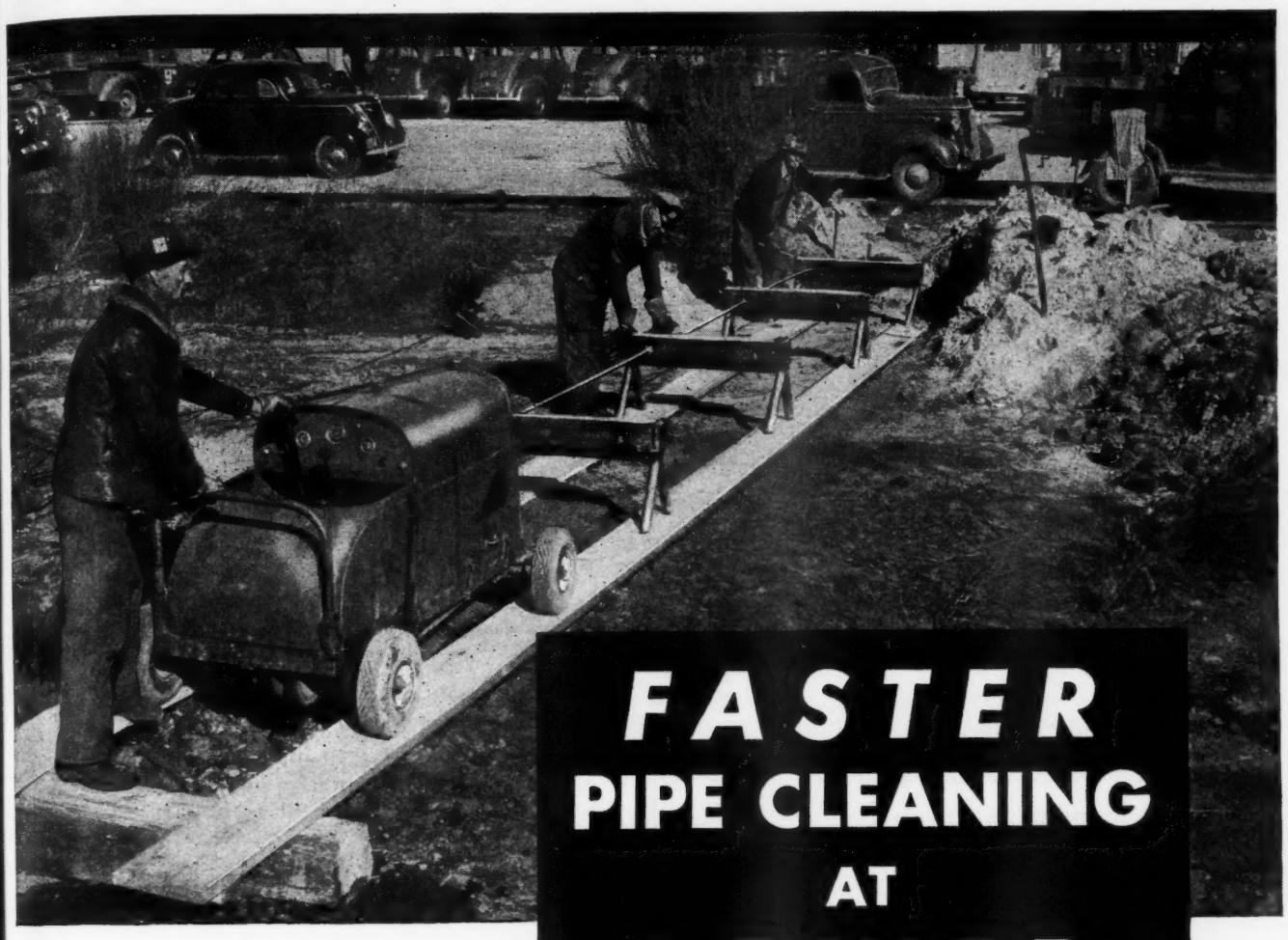
Fig. 1a—Curve of velocity in a stream.

(c). The vapor pressure is another factor influencing suction lift. Vapor pressure is the pressure existing at the surface of any liquid when the space above the liquid is confined or closed. This vapor pressure increases with the temperature; therefore the warmer the water is, the less the suction lift possible. Boiling water cannot be lifted by suction. The possible lift for water at 75° F is about 1 ft. less than for water at 32°; at 100° F it is 2.2 ft. less; at 150° F it is 8.6 ft. less; and at 200° F it is 26.6 ft. less. In other words, water having a temperature of 150° F can be lifted to a theoretical height of only 25.3 feet (less than this when above sea level); and water with a temperature of 200° F can be lifted only 7.3 feet under the most favorable conditions.

8. Limit of Accuracy in Hydraulic Computations.—Calculations of flow in pipes and channels and over weirs are approximate and practically never represent what actually happens. Some error always exists, as it is not possible to make exact allowances for all the factors that affect flow. For instance, computations of the flow in long pipes may not be within 5% to 10% of actual results. Actual flows over weirs, even when all conditions are very carefully controlled, may be as much as 5% at variance from computed results, moreover, such flows are affected by minor variations in the shape or condition of the edge of the crest of the weir. Normally such variations or errors are unimportant. For instance, the amount of water to be handled is seldom known exactly. A supply line is designed for conditions assumed to exist a number of years in the future, and not for those existing today. In addition, the demand for water and the production of sewage varies from day to day. Finally, pipe for these purposes is made in standard sizes; if computations indicate the need for an 8½-inch water pipe, a 10-inch pipe is used; similarly, where computations indicate the need for a 13-inch sewer, the next larger standard size, 15-inch, is normally selected.

9. Hydraulic Definitions.—The *velocity* in a pipe, channel, or stream, refers to the mean or average velocity. The various particles of water in a river have various rates of velocity—less near the banks and most in the middle at the surface. In pipes, the greatest rate of flow usually occurs in the middle of the pipe. In a stream, the average velocity at any point in the stream is about 0.8 of the surface velocity at that point. A more accurate method is to find the velocity at 0.2 and 0.8 of the depth, at points taken at a uniform distance apart across the stream, and average these. In pipes, the velocity, when the lower end of the pipe is discharging freely, depends upon the length of the pipe; the condition of its interior; the number of valves, bends or other obstructions; and the static head or pressure on the outlet end of the pipe.

The *static head* is the vertical distance in feet (the difference in elevation) between the free water level of the source of supply and the free surface of the water into which it is discharged. The *effective head* at any point in a conduit is equal to the static head less



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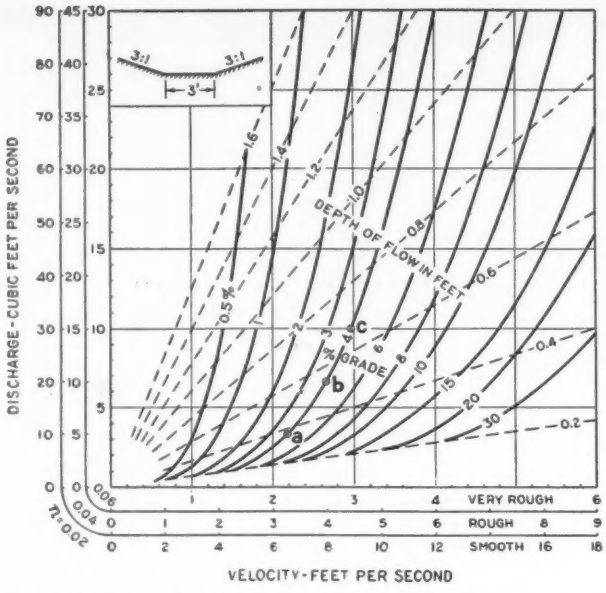

Fig. 3a—Relations between grade, depth, discharge, and velocity for a channel 3 feet wide at the bottom and having 3:1 side slopes, for various linings.

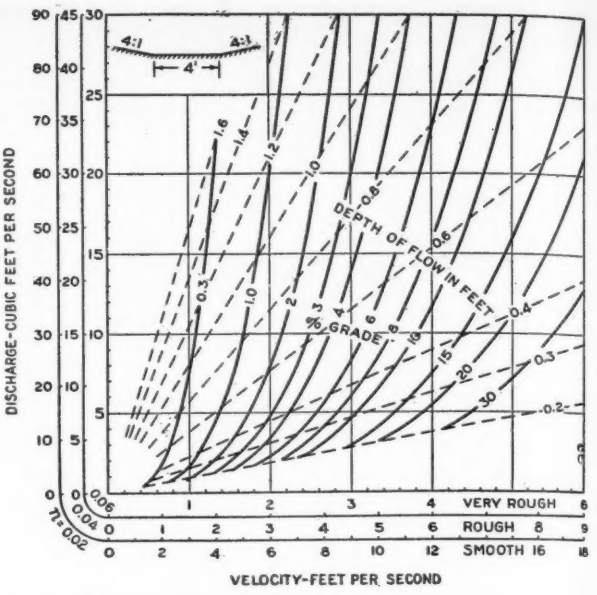

Fig. 3b—Relations between grade, depth, discharge, and velocity for a channel 4 feet wide at the bottom and having 4:1 side slopes, for various linings.

friction and other losses above that point. *Velocity head* is that part of the effective head that is represented by the velocity of flow at the point in question, equals the vertical distance through which a body must fall in a vacuum to acquire the velocity v, $= \frac{v^2}{2g}$. The effective head at any point, less the velocity head at that point, is the *pressure head;* which may be negative, as in the throat of a Venturi meter.

10. Elemental Factors in the Flow of Water.—Since water is a perfect fluid, it tends to seek the lowest possible level. In obedience to the laws of gravity, it flows downward through watercourses or other channels, conduits or pipes. The natural laws and the principles governing such flow of water have been studied very carefully because an accurate knowledge of these is important in nearly every job dealing with water or sewage, and on many other types of engineering work also.

From these studies, formulas have been developed which permit sufficiently accurate determination of flows of water under all usual conditions. While many of these formulas are complicated and require a knowledge of higher mathematics, simple tables and graphs have been worked out that give results sufficiently accurate for practical purposes, as stated in Par. 1. It is not necessary, therefore, to be able to compute results by such formulas, but it is desirable that the proper terms and usages commonly used in hydraulics be understood thoroughly.

Heads or differences in elevation should be determined accurately. Do not guess at heads. An engineering survey may cost very little when compared to the cost of an error. Before pipe lines are laid, surveys should be run to insure that the elevation or head available is sufficient to deliver the desired amount of water through the size of pipe it is intended to use. High points in pipe lines are undesirable, as indicated later, and should be permitted only where it is certain that they will not interfere materially with the flow. Careful planning is an essential element in any job.

11. Hydraulic Terms and Usages.—(a). *Slope* is the rate of fall. In hydraulics this term is generally meant to indicate the fall per 1000 feet. In formulas, slope is commonly indicated by s. A slope of 5 feet in $1000 = \frac{5}{1000}$ or $5 \div 1000 = .005$. The term $s = .005$ means the slope is 5 ft. in 1000 feet of *horizontal* distance. However, in most cases in hydraulics the difference between the horizontal length and the actual length of the pipe or canal is very small and can be neglected, and the actual length of the pipe or canal is used. Even on a 10% slope, where there is 100 feet of fall in 1000 feet ($s = .100$), the error due to using the actual length of the pipe instead of the horizontal or level length is only about ½ of 1%.

(b). The *hydraulic gradient* is the line joining the elevations to which the water in a pipe line would rise in vertical tubes connected to it while water is flowing through the line. If the end of the line is plugged, the hydraulic gradient is a horizontal line; but if the line is allowed to flow freely, friction and other losses in the pipe reduce the pressure as the outlet is approached. Vertical distance from pipe to hydraulic gradient at any point is equal to the pressure head at that point. If possible, there should be no point in a pipe line that intersects or rises above a straight line drawn from the outlet of the pipe line to the surface of the reservoir from which the pipe draws. Fig. 2 shows such construction. A high point of this nature reduces the volume of water delivered.

(c). The *wetted perimeter* is also important in computing flows. This term indicates that part of the per-

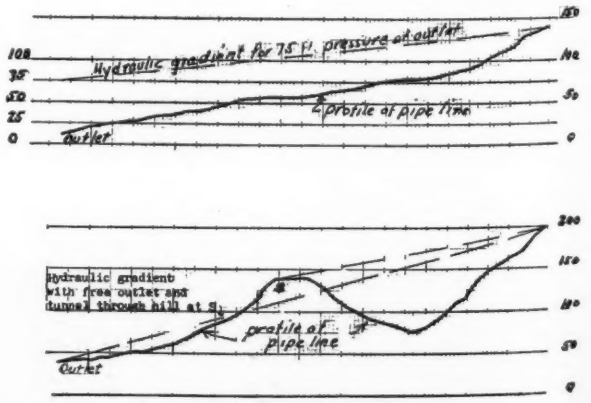
Hydraulic gradient for 75 ft. pressure at outlet
Profile of pipe line
Outlet
Hydraulic gradient with free outlet and tunnel through hill at S
Profile of pipe line
Outlet

Fig. 2—Showing how high point in pipe line interferes with flow.

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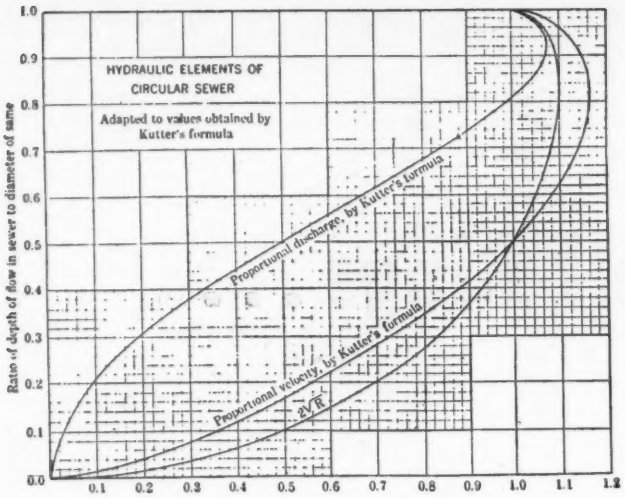

Fig. 4—Ratio of velocity and discharge at different depths to those with full pipe.

imeter of a cross-section of the conduit that is in contact with the flowing liquid, and therefore that where friction between water and conduit surface is developed. In water pipes, which normally flow full of water, the wetted perimeter is the entire interior wall of the pipe; for round sewers flowing, let us say, half-full, it is one-half the interior wall. For canals having straight or sloping walls, the amount of wetted perimeter depends on the shape of the canal or conduit and the depth of flow in it. For example, remembering that, in hydraulic formulas, pipe sizes are always expressed in feet:

(1) An 8-inch water pipe flowing full has a wetted perimeter of 0.667 x 3.1416 = 2.09 ft.

(2) A 12-in. sewer flowing half full has a wetted perimeter of 1 x 3.1416 ÷ 2 (since it is but ½ full) = 1.57.

(3) A rectangular conduit 4 ft. wide carries 1 foot of water. The wetted perimeter amounts to 1 + 4 + 1 = 6 ft. — that is, the water touches the side walls to a depth of 1 ft. on each side and, of course, wets the entire 4-ft. width of the bottom.

The wetted perimeter is essential in hydraulics measurements because it affects the *hydraulic radius,* which will be discussed next. In hydraulic tables and formulas, the wetted perimeter is usually designated as p.

(d). The *hydraulic radius* of a pipe or conduit is the cross-sectional area of the stream of water divided by the wetted perimeter. For instance, an 8-in. pipe flowing full has a cross-sectional area of .667 x .667 x 3.14 x ¼ = 0.35 sq ft. The wetted perimeter, as indicated in the preceding paragraph, for an 8-inch pipe is 2.09 ft. The hydraulic radius, therefore, is 0.35 sq. ft. ÷ 2.09 ft. = 0.167 ft. The hydraulic radius of any circular pipe that is flowing either full or half full is ¼ the diameter. The cross-sectional area of the 12-inch sewer flowing ½ full is ½ (1 x 1 x 3.14 x ¼) = 0.39; and the wetted perimeter, as previously shown, is 1.57. Then the hydraulic radius is 0.39 ÷ 1.57 = 0.25 ft., or ¼ the diameter.

In the case of the rectangular conduit (3) in paragraph c above, the cross-sectional area of the stream is 1 x 4 = 4 sq. ft. The wetted perimeter was shown to be 6 ft. The hydraulic radius is therefore 4 ÷ 6 = 0.667 ft. If a conduit is 4 ft. wide and 3 ft deep, the cross-sectional area of water is 12 sq. ft., and the wetted perimeter is 10 ft. The hydraulic radius is therefore 12 ÷ 10 = 1.2 ft. To illustrate the variation caused by a shallow stream, assume this conduit is 12 ft. wide and 1 ft. deep. The cross-sectional area is still 12 ft.; the wetted perimeter is 12 + 1 + 1 = 14 ft. and the hydraulic radius is 12 ÷ 14 = 0.86 ft.

The value of the hydraulic radius, commonly indicated by r in hydraulic formulas, indicates quite clearly the flow qualities of a conduit or channel; for while p is the main factor in determining the amount of friction developed (velocity and other conditions being equal), the energy for overcoming such friction is proportional to the volume of water flowing, which in turn is proportional to the area; and r indicates the relation between these. With all other conditions the same, the larger the hydraulic radius, the better the flow quality.

(e). Long and Short Pipes; Tubes.—(a). The length of a pipe, as compared to its diameter, is important in hydraulics. A *long* pipe is one whose length is at least 1000 times its diameter—that is 500 ft. of 6-inch pipe, 1000 ft. of 12-inch, etc. A *short* pipe has a length less than 1000 times its diameter, but more than 60 times. A *very short* pipe has a length not greater than 60 times its diameter. A *standard tube* has a length 2½ times its diameter.

The length of lines in pipe formulas is usually indicated by l.

12. Factors Affecting Flow.—Among the factors that affect the flow of water in pipes and channels are the following:

(a). The friction of the water against the walls of the pipe or the bottom and side walls of a canal. The rougher the walls, the greater is the friction.

(b). The size of the opening in the pipe. By reference to paragraph 11, it will be noted that the hydraulic radius for a small pipe is less than for a large one. Thus the wetted perimeter of a 12-inch pipe is 3.14 ft., while for a 24-inch pipe it is 6.28 feet. The cross-sectional area of the 12-inch pipe is 0.78 sq. ft. and of the 24-inch pipe 3.14 sq. ft. Then the hydraulic radius of the 12-inch pipe is 0.25 ft. and of the 24-inch pipe is 0.50 ft.

(c). The age of the pipe often influences the flow because, as pipes remain in use, the inner surface usually becomes rough and pitted, deposits may form reducing the area available for the flow of water, or moss may grow on the interior, producing both a roughening effect and a decreased section.

(d). The longer the pipe the greater the resistance to flow, since each lineal foot exerts its own resistance.

Fig. 5—Section of silted main before cleaning.

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Fig. 6—Deposit removed from one bad run of pipe.

(e). Increased pressure affects friction only on so much as it causes greater velocity.

(f). Valves and other fixtures, bends, tees, etc., provide some increased resistance to the flow, due to interference with the stream of water, through eddies, etc.

(g). Obstructions in the pipe, as fins from improperly made joints, interfere with the flow. Air bubbles collected at high points in the line obstruct the flow of water.

13. Friction.—The resistance to the flow of water through a pipe is called *friction*, or *friction loss*, or *friction head*. The amount of friction depends on a number of factors, including the following:

(a). The length of the pipe: A pipe that is 2000 feet long offers twice as much resistance to flow as one that is 1000 ft. long. This means that computations can be based directly on the length of the pipe.

(b). The velocity: Just as in the case of an automobile, the faster it goes, the greater the power required. In fact, the friction loss varies as the square of the velocity, being about 4 times as great for a velocity only twice as great, and nearly nine times more when the velocity is 3 times as great. For instance, a velocity of 1 ft. per second causes a loss of head of 0.85 ft. in 1000 feet of 6-inch pipe; with a velocity of 2 feet per second in the same pipe, the loss of head is 3.22 feet; with a velocity of 3 feet per second, other conditions being the same, the loss of head is approximately 7.0 ft.

(c). The diameter of the pipe: The friction is inversely proportional to the diameter of the pipe, that is, it is about ½ as much for an 8-inch pipe as for a 4-inch. For instance the friction loss in 1000 ft. of 4-inch pipe at 1 ft. per second velocity is 1.33 ft., while under the same conditions it is but 0.62 ft. for an 8-inch pipe. Paragraphs 11d and 12 explain this relation more fully. However, a short piece of smaller diameter pipe inserted in a larger line does not materially reduce the capacity of the line. Some cities stock a limited number of sizes of valves, using a 6-inch valve, for instance in 6-in., 8-in., and even 10-in. lines; a 12-in. valve in 12-in. to 18-inch pipes, etc. The change in size should be gradual, as by a reducer.

(d). The condition of the pipe interior, as smooth or rough, greatly influences the flow of water in the pipe and in all formulas for flow allowance is made for this factor. Experience has shown that, as pipes become older, the interior usually becomes rougher and the carrying capacity of the pipe decreases. Thus in the Williams and Hazen formula, which is commonly used in computing flows in water pipes, different values for the modifying coefficient c are used, according to the estimated condition of the interior of the pipe. Common values of c for various kinds and ages of pipe are as follows:

Kind of Pipe	*Corresponding Value of c*
Best and new straight cast iron pipe.....	140
Good new cast iron pipe.....	120
Cast iron pipe 10 to 12 years old.....	110
Cast iron pipe 15 to 20 years old.....	100
Cast iron pipe 25 to 30 years old.....	90

These values of c can be used in connection with loss-of-head tables presented later; full explanation of their use will be given then.

(e). Pressure in the pipe has no effect on the friction loss and therefore may be wholly neglected in computing flows.

(f). Resistance to Flow Through Valves and Fittings.—A valve, even when open, interferes somewhat with the flow of water through a pipe; if the valve is partly closed, the interference will be greater. A globe valve offers more resistance than a gate valve; so will an angle valve. Elbows, sudden reductions or increases in size of pipe, tees and other fittings also interfere with the flow. Gradual reductions or increases in size cause little loss of effective head.

This resistance to flow is usually measured in terms of equivalent length of straight pipe, and in computing the resistance of flow this equivalent in length is added to actual length of the pipe. For instance, it has been determined that the resistance (consumption of effective head) of a 6-in. standard elbow to the flow of water through it is the same as the resistance of approximately

Fig. 7—A short bend causes more loss of head than would a long curve.

16 feet of straight pipe. Therefore, if in a 6-in. line 1000 ft. long, there are two elbows, the equivalent length of line is 1000 + 16 + 16, or 1032 ft., and this length should be used in computing flow.

Table No. 1, below, shows the approximate resistance to flow, of various valves and fittings, for several sizes of pipe.

Example (1).—What is the equivalent loss of head in terms of straight pipe of a 12-inch gate valve ¼ closed?

Solution.—From Table I, see line 4, and under 12″ read the answer—it is the same head that would be lost in a straight run of 40 ft. of 12-in. pipe.

Example (2).—An 8-inch line takes off from another 8-inch line by a T. What is the equivalent loss of head due to the T?

Solution.—From the table, line 9, read under 8-inch the loss of head is equivalent to 47 ft. of 8-inch pipe.

Example (3).—If no water is being taken off through the line mentioned in Example 2, what is the equivalent loss of head in the main 8-inch line due to the presence of the T?

Solution.—Line 13 gives the equivalent loss for the run of a standard T. In the 8-inch column, this is shown to be the same as a straight line of 8-in. pipe 14 ft. long.

Example (4).—There are two 45° elbows in a 12-inch line. What is the equivalent loss of head?

Solution.—From line 12, of the table, the equivalent loss of head for a 12″ 45° elbow is shown to be 12½ ft. For 2 such elbows, the loss would be 2 x 12½ = 25 ft. of pipe.

Example (5).—A 12-inch line is suddenly reduced to 6-inch. What is the equivalent loss of head in feet of pipe due to the reduction?

Solution.—d = 6 inches; D = 12 inches, d/D = ½. From line 15 of the table, the loss is equivalent to 6 feet of 6-inch pipe.

Example (6).—A 6″ valve is used in a 10″ line. What loss of head is caused thereby?

Solution.—This will depend upon the velocity of flow in the pipe. If we assume 2 ft. in the 10″ pipe, we find (Table II) the head lost is 1.8 ft. per 1,000 ft. of pipe, the quantity flowing being 490 gpm. The loss in a 10″ valve would be equivalent to that in 6′ of straight pipe or .006 x 1.8 = .0108 ft. head.

The same quantity flowing through a 6″ valve would have a velocity of 5.5 ft.; the loss in the valve would be equivalent to that in 3 ft. of straight, or .003 x 22.1 = .0663; which is .0555 ft. head additional loss.

Calculating similarly for a v. of 1 ft. in the 10″ pipe (=2.78′ in a 6″ pipe), we find the loss in a 10″ valve would be .003; in a 6″ valve .018; additional loss by use of 6″ valve, 0.015 ft. The loss increases approximately as the square of the velocity, so for a v of 4 fps in the 10″ pipe, the additional loss would be about 0.22 ft. head.

Note: For contractions and enlargements, d is the size of pipe shown in the table and is always the smaller pipe. D is the larger pipe. Thus for d/D = ¼, if d = 4″, D = 16″; for d/D = ½, for 4″ pipe, D = 8″; for d = 6″, D = 12″. The only equivalent d/D = ¾ in the sizes of pipes shown in this table is d = 6, D = 8″; d = 12, D = 16.

These resistances, friction, etc., cause a permanent loss of effective head. Changes in velocity merely cause a transfer between velocity head and pressure head, the sum of the two remaining constant, except for slight permanent loss due to turbulence caused by the change in area of the water.

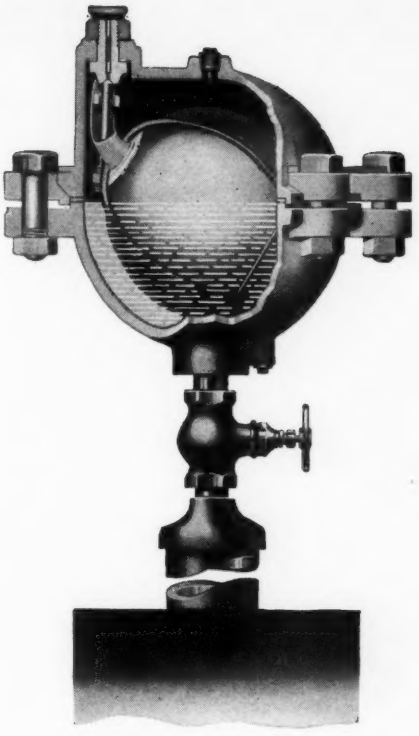

Fig. 8—Simplex air relief valve.

(g). Air Locks.—When pipes carrying water under pressure pass over hills, air bubbles may collect at the high points in the lines and form partial locks, obstructing the flow of water. These obstructions can be prevented by placing air relief valves at the high points in the lines. These valves automatically release air as it collects, but close before water can escape. If a pipe line does not deliver the expected or computed amount of water, it should be inspected for leaks and for high points where air locks may form.

14. Computing Flows.—(a). The elementary formula for flow is based on the following:

Quantity of flow = area of pipe opening x velocity of flow.

The area of pipe opening is known or can be com-

TABLE I

RESISTANCE TO FLOW DUE TO VARIOUS VALVES AND FITTINGS

(Fractions of feet are omitted)

		Resistance to flow in equivalent feet of straight pipe						
1.								
2.	Type of fitting. Size:	4″	6″	8″	10″	12″	14″	16″
3.	Gate valve, open	2	3	5	6	7	8	9
4.	Gate valve, ¼ closed	14	19	26	33	40	47	53
5.	Gate valve, ½ closed	70	100	140	170	200	230	270
6.	Gate valve, ¾ closed	280	400	550	700	845	980	1120
7.	Globe valve, open	120	160	210	—	—	—	—
8.	Angle valve, open	57	83	110	140	165	190	225
9.	Standard T takeoff	22	36	47	62	74	85	100
10.	Standard elbow	11	16	21	27	32	37	42
11.	Long sweep elbow	7	11	14	17	20	23	26
12.	45° elbow	5	8	10	13	15	17	19
13.	Run of standard T	7	11	14	17	20	23	26
14.	Run of T reduced ½	11	16	21	27	32	37	42
15.	Sudden contraction							
	d/D = ¼	5	8	—	—	—	—	—
	d/D = ½	4	6	8	—	—	—	—
	d/D = ¾	—	3	—	—	7	—	—
16.	Sudden enlargement							
	d/D = ¼	11	16	—	—	—	—	—
	d/D = ½	7	11	14	—	—	—	—
	d/D = ¾	—	10	—	—	19	—	—

puted from the pipe size. The velocity of flow is dependent on the head or pressure of water as affected or modified by the friction factors enumerated in the preceding paragraphs.

Formulas have been developed which take all these factors into consideration. By substituting in these formulas the values of pipe size, length of pipe and pressure of water, with allowance for the condition of the interior of the pipe, the discharge can be computed. The use of such formulas involve higher mathematics. It is easier and simpler to utilize tables which have been compiled by working out such formulas. These tables and the methods of using them will be described in the following sections.

(b). Use of Flow Tables.—In order to use the tables given herewith, for estimating flow, the following information is required.

(1) The size of the pipe.

(2) The length of the pipe in feet.

(3) The difference in elevation between (a) the water surface at the intake end of the pipe and the end of the pipe or the water into which it discharges. (b) If more convenient, the gauge pressures can be taken at these points and converted into feet of elevation as described in Paragraph 7.

(4) Information on the condition of the interior of the pipe, as outlined in Paragraph 13d.

The tables herewith show the loss of head in feet per 1000 feet of pipe. In using these tables, the following are essential:

(1) These tables refer to new pipe, for which the value of *c*, Paragraph 13d, is normally 120 to 130, depending on the care with which it is laid and the straightness of the lines, but also on the size of the pipe to some extent. For sizes 16-inch and larger, use $c = 130$; for smaller sizes use $c = 120$.

(2) For pipe 10 to 12 years old, divide the figures in the table for head lost by 1.18; for pipe 15 to 20 years old, divide the figures in the table for head lost by 1.40; and for pipe 25 to 30 years old divide by 1.70. These figures are based on average experience. If your pipes do not tuberculate or deposits do not form in them, these figures will show greater losses than actually may occur. If your pipes do tuberculate or coat badly, a greater allowance should be made.

The figures for head lost are divided by 1.18, 1.40 or 1.70 because the effect of a roughened pipe interior is to reduce the flow to what it would be with a smaller loss of head with a clean pipe.

To use the tables, obtain (1) the difference in feet of elevation between the inlet water surface of the pipe and the outlet water surface, or obtain the pressure in pounds at the outlet and convert this to feet; (2) the length of the pipe; and (3) the size of the pipe it is intended to use.

Divide the feet of elevation or head by the length of the pipe, including losses for valves, bends, etc., in thousands of feet. This gives the head available per 1000 ft.

Example (1).—A pipe is 5000 feet long and the head available is 90 feet. The head per 1000 feet $= 90 \div 5 = 18$ ft.

Under the size of pipe it is intended to use, in Table II, read in the column headed "Head Lost per 1000 ft. of pipe" find the figuring corresponding to the available head. In the same line, but the next column will be shown the velocity, and in the third column will be shown the discharge in gpm.

Example (2).—It is intended to use new 6-inch pipe. The head available, as shown in Example (1) above is 18 ft. per 1000 ft. Read under 6-inch pipe; with a loss of head of 18.5 ft. per 1000, the velocity is 5.0 ft. per second and the discharge is 441 gpm. Since the head available is a little less than 18.5 ft., the discharge will be slightly less. Also by reference to the 8-inch pipe table, it will be seen that nearly 940 gpm will be delivered by an 8-inch pipe for the same loss of head. It will also be noted that a 4-in. pipe would deliver only about 157 gpm under the same conditions.

When a value lies between the values given in the table, it will usually be sufficiently accurate to average the figures. Other methods of doing this, that give slightly more exact answers will be shown in the following examples.

(1) A new 6-inch pipe, 5200 feet long, leads from a reservoir which has a water surface elevation of 610 feet. The outlet of the pipe is at elevation 520. How much water will the pipe discharge while the pipe is new, and how much will it discharge after 20 years?

Solution.—The head available is $610 - 520 = 90$ feet. The head per 1000 feet is found by dividing 90 by 5.2, which gives 17.3 ft. per 1000. Referring to the table for 6-inch pipe, it is found that for 15.2 feet of head lost, the velocity is 4.5 ft. per second and the discharge is 397 gallons per minute, while for 18.5 ft., the velocity is 5.0 ft. per second and the discharge 441 gpm. Obviously the actual lost head, which is 17.3 ft., is between 15.2 and 18.5 and the discharge will be more than 397 gpm and less than 441 gpm. The actual velocity and discharge will be

$$\text{discharge } \frac{18.5-17.3}{18.5-15.2} \times (441-397) + 397$$

$$= \left(\frac{1.2}{3.3} \times 44\right) + 397 = 413 \text{ gpm}$$

$$\text{velocity} = \frac{18.5-17.3}{18.5-15.2} \times (5.0-4.5) + 4.5$$

$$= \left(\frac{1.2}{3.3} \times 0.5\right) + 4.5 = 4.68 \text{ fs.}$$

According to information previously given, pipe that is 20 years old will have a loss of head about 1.4 times as great as new pipe. The available head is 17.3 ft. To convert this to conditions 20 years in the future and to determine the head available then, divide 17.3 by $1.4 = 12.3$ ft. per 1000. Under 6-inch pipe, calculating as above it is found that, with a loss of head of 12.3 ft. per 1,000 feet of pipe, the flow will be a little more than 352 gpm.

(2) A 4-inch pipe 3300 ft. long is to be joined to a main in which the pressure is 50 pounds per sq. inch. The connection is by means of a T, and there are 2 elbows and 6 hydrant T connections in the line. How much water will the line deliver?

Solution:

The line is	3300 ft. long	
2 elbows add	22 ft.	(see Table I, line 10)
The T takeoff adds	22 ft.	(see Table I, line 9)
The 6 hydrant Tees add	42 ft.	(see Table I, line 13)
Total equivalent length	3386 ft.	

The available head is 115 feet, due to the pressure of 50 pounds (See Par. 7). The head available per 1000 feet is $115 \div 3.38 = 34$ ft. By reference to Table II, it will be seen that for a loss of head of 34.5 ft. per 1000 ft., the discharge from a 4-inch pipe will be about 215 gpm.

(3) What size main must be provided to deliver 450 gpm at the end of a 4000-ft. line, the initial pressure being 50 pounds and assuming pipe 20 years old.

Solution.—A pressure of 50 pounds equals a head of 115 ft. With a line 4000 ft. long, the available head is $115 \div 4 = 28.7$. For pipe 20 years old, this available head must be reduced by dividing by 1.4; therefore the available head is $28.7 \div 1.4 = 20.5$ ft. By reference to the tables, it will be seen that with 20.5 ft. of head per 1000 ft., 4-inch pipe would deliver less than 176 gpm; 6-inch pipe would deliver between 441 and 485 gpm; and 8-inch pipe would deliver more than 940 gpm. A 6-inch pipe will be needed. To find the exact flow, use the method described in the preceding solution.

15. Measuring Flows.—Flows may be measured as well as computed. Numerous devices for measuring flows are available. These include meters, weirs and similar devices. There are three common types of meters—disc, current and flow.

(a). Disc Meters.—In the disc meter, the passage of water through the meter revolves a disc, usually made of hard rubber, which operates a gear driving a register placed on top of the meter. This type of meter is usually used on services or other small pipes, less than 1½ or 2 inches in diameter, though such meters are available in sizes up to about 6-inch. In general, such

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Fig. 9—Measuring chamber and flat disc of a disc meter.

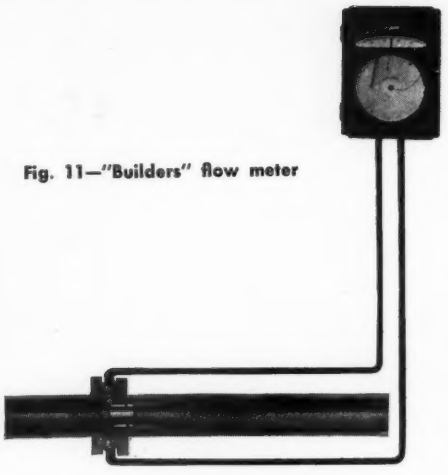

Fig. 11—"Builders" flow meter

meters are very accurate. Specifications of the American Water Works Association require that the meter dials indicate not less than 98% nor more than 102% of the actual flow with normal limits. At very low flows, the accuracy is less and the meter will ordinarily under-measure (rather than over-measure) the flow—sometimes as much as 10%. The table herewith indicates the requirements of the AWWA.

Normally the meter should not, for best accuracy, be operated at either the minimum or maximum rates shown in the second column of the table.

Meter testing sets are available from a number of manufacturers. These, for small meters, normally consist of a tank and scale, permitting the water passed by the meter to be weighed or otherwise measured, and thus checked against the meter reading.

Registration Requirements, A.W.W.A. Specifications

Size	*Normal test flow limits, gal. per min.*	*Minimum test flow, gal. per min.*	*Gallons per min. at 25 lb. lost head*
⅝	1 to 20	¼	20
¾	2 to 34	½	34
1	3 to 53	¾	53
1½	5 to 100	1½	100
2	8 to 160	2	160
3	16 to 315	4	315
4	28 to 500	7	500
6	48 to 1000	12	1000

(b). Current Meters.—The current meter consists of a wheel with curved blades inserted in the pipe. The velocity of the water passing through the pipe

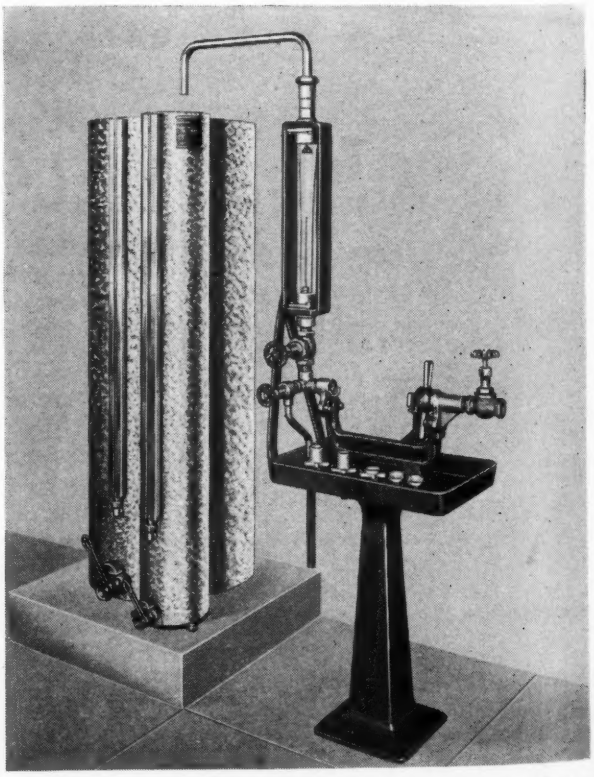

Fig. 10—Ford meter testing machine, with "testerate" indicator and calibrated tanks.

TABLES OF PIPE FRICTION AND FLOW

TABLE II

For new, clean, smooth cast iron or steel pipe. (For old pipe see Paragraph following the Tables)

4-Inch Pipe

Head lost per 1000 ft. pipe	*Velocity in Pipe*	*Discharge G.P.M.*
1.3	1.0	39
2.9	1.5	59
5.1	2.0	78
7.7	2.5	98
10.9	3.0	117
14.6	3.5	137
18.8	4.0	157
23.6	4.5	176
28.8	5.0	196
34.5	5.5	215
40.6	6.0	235

8-Inch Pipe

0.6	1.0	157
1.4	1.5	251
2.3	2.0	313
3.6	2.5	391
5.0	3.0	470
6.8	3.5	549
8.8	4.0	627
11.0	4.5	705
13.4	5.0	783
16.0	5.5	860
18.9	6.0	940

6-Inch Pipe

Head lost per 1000 ft. pipe	*Velocity in Pipe*	*Discharge G.P.M.*
0.9	1.0	88
1.9	1.5	132
3.2	2.0	176
4.9	2.5	220
7.0	3.0	264
9.4	3.5	308
12.1	4.0	352
15.2	4.5	397
18.5	5.0	441
22.1	5.5	485
26.1	6.0	529

10-Inch Pipe

0.5	1.0	245
1.1	1.5	392
1.8	2.0	490
2.8	2.5	612
3.9	3.0	734
5.3	3.5	857
6.8	4.0	979
8.5	4.5	1105
10.4	5.0	1225
12.5	5.5	1350
14.7	6.0	1470

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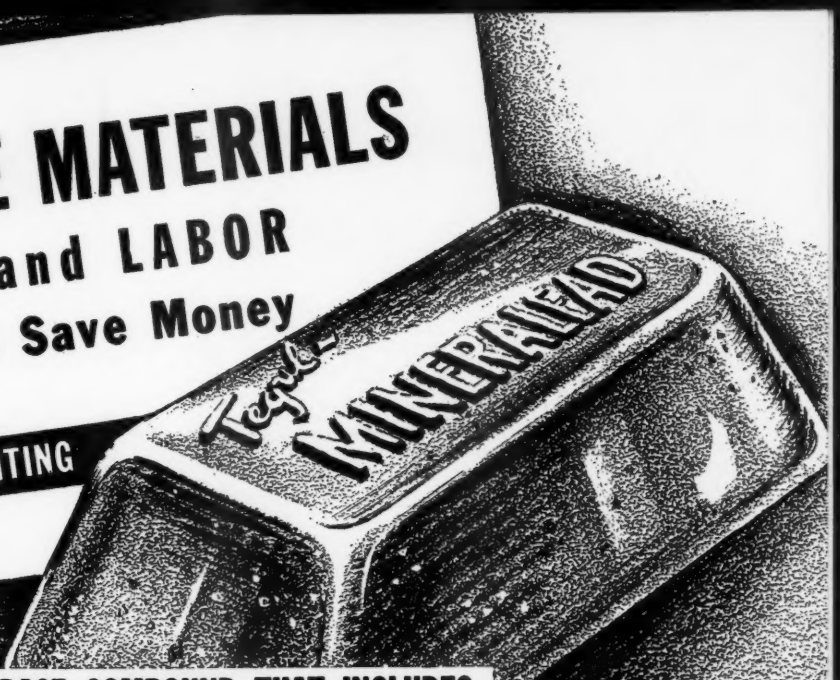

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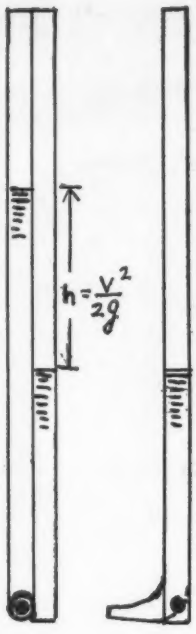


Fig. 12 — Front and side view of a pitot tube.

causes the wheel to revolve at a rate depending on the velocity. Current meters are simple and fairly accurate for velocities in the pipe greater than about 2 feet per second. At lower velocities, the wheel may not move, or will under-measure. Such current meters are made in sizes from about 4-inch up to 12-inch or larger. They are normally fitted with gears so as to indicate the amount of flow directly on a dial. If in good condition, and operated within the velocity ranges of 2 to 5 feet per second, current meters inserted in a pipe will give sufficienty reliable results.

(c). Compound Meters.—This type of meter consists of a combination of a small disc meter and a larger current meter. A built-in device provides that small flows are passed through the disc meter, but when the capacity of this has been reached, the flow is diverted through the current meter. As a result, good accuracy is obtained since each meter works within its most effective range. The total flow is usually indicated by gear trains on a dial. The two meters are usually assembled in one case or covering, or are closely coupled together. Such meters are made in large sizes, generally in 4-inch and larger.

(d). Flow Meters.—When the area of a pipe is decreased, the velocity of the water flowing through it is increased and the pressure thereby decreased. Therefore, if the diameter of a short section of the pipe is reduced, and devices for indicating the pressure are inserted ahead of and also in the reduced-size section, means for measuring the flow are available, due to the fact that the relative pressure in these devices vary with the velocity of the flow. The devices for indicating the pressure commonly consist of small tubes, containing mercury. For any given flow, the difference between the heights of the mercury in the two tubes is definite and permits almost exact calculation of the flow. By means of floats or by electrical action, the flow may be indicated on a dial.

Each meter must be calibrated and adjusted to the flow for that particular size of pipe and range of pressures.

The decrease in section of the pipe may be accomplished by means of a Venturi tube as shown herewith, Fig. 11, or a modified orifice plate set in the pipe.

Meters of this type are adapted for use in pipes from 4 or 6 inches diameter up to the largest pipes or conduits made.

(e). Measurement by Pitot Tubes.—The Pitot tube consists of a tube with a short section bent at a right angle at the bottom, which is inserted into a water pipe through a tap, or into a flowing stream of water, the tube being held vertical and so turned that the opening of the bottom bend faces the current, which will cause the water to rise in this bent tube to a height equal to the sum of the pressure head and the velocity head of flow in the pipe. Usually there is a straight companion tube connected alongside the bent tube and with its lower end at the same elevation. The water will rise in the straight tube to a height equal to the pressure head in the pipe, and the difference between the heads in the two tubes is the velocity head, from which the velocity can be calculated. A mercury tube or other device is normally used in measuring velocities in pipes under pressure.

Equipment of this type is available from several manufacturers, who furnish specific directions covering each instrument. Theoretically the difference in readings in the two tubes should equal the velocity head, but allowance must be made for departures from ideal conditions, and each instrument must be calibrated. Velocities are normally measured at several points within the pipe in order to obtain a mean velocity head. Under average conditions, the mean velocity is about 0.83 of that measured at the center of the pipe.

Pitot tube equipment is convenient to use and suitable for quick, approximate determinations. It is not an accurate instrument, but is suitable for measurements ordinarily needed in water works procedures. It is best to purchase an outfit from a manufacturer and have one or two operators trained in its use by the manufacturer. It can be used for a number of purposes, including finding large leaks in a supply line, determining approximate flows in pipes, etc.

(f). Orifices.—Orifices can be used to measure pipe discharge in either of two ways: (1) The orifice is placed at the end of the pipe; (2) A thin plate containing an orifice is placed in the pipe, as bolted between two flanges.

In case (1), a cap, in which a hole has been drilled, is screwed on the end of the pipe, or a plate with a hole in it is bolted onto the pipe end. In either case, the hole should be round, centered in the pipe and smoothly cut and beveled, as shown in Fig. 13. A pressure gauge is necessary, which should be inserted in the pipe about 1 pipe diameter back from the orifice —that is, 6 ins. back for a 6-in. pipe, 10 inches back for a 10-inch pipe, etc.

The computation of the discharge is not difficult. Assume that the diameter of the orifice is ½ the diameter of the pipe—that is 3 ins. for a 6-inch pipe, 4 ins. for an 8-inch, etc.—the discharge formula is

$$Q = c\ a\ \sqrt{h}$$

Where Q = discharge in cubic feet per second, c is a coefficient which for an orifice opening ½ the size of the pipe is 5.2; a is the area of the orifice in sq. ft.; and h is the head on the center of the orifice, in feet. It is easier to use this formula with gallons per minute discharge and pounds of pressure. Then:

Gallons per minute = 449 x 5.2 x A x B

Where A = the area in sq. ft. of the orifice (See Table IV).

B = the square root of head on the center of the orifice (See Table V).

Example 1: A 6-inch pipe discharges through a 3-inch orifice of the type shown in the accompanying illustration (Fig. 13).

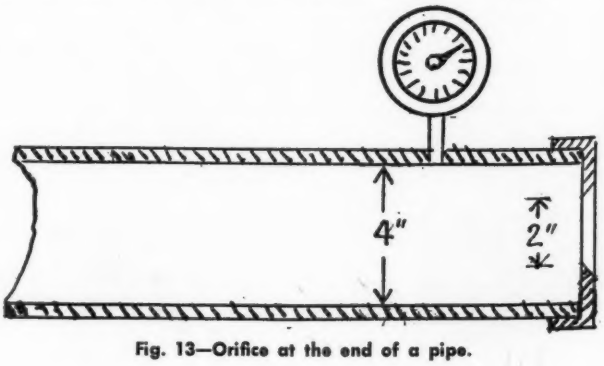
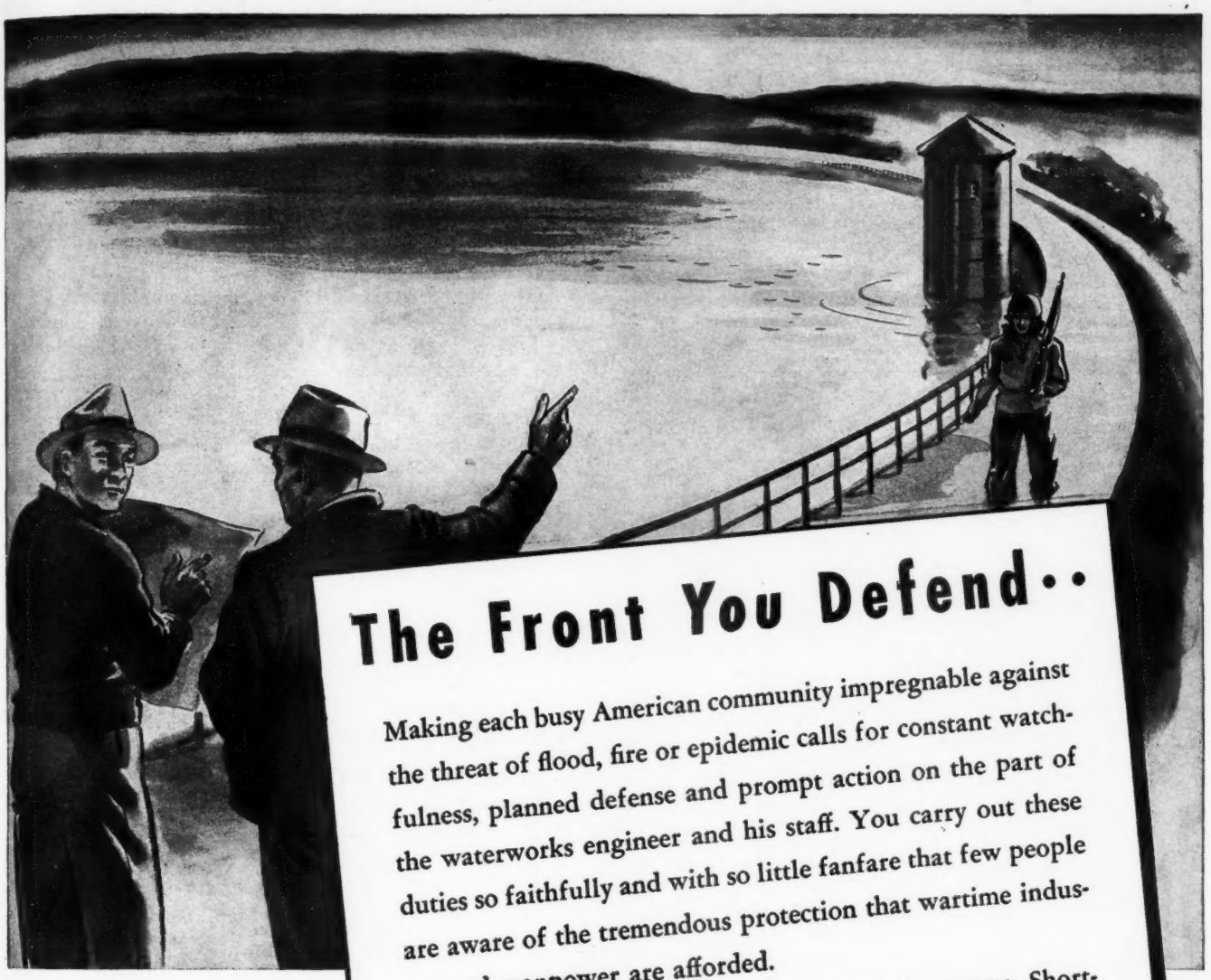


Fig. 13—Orifice at the end of a pipe.



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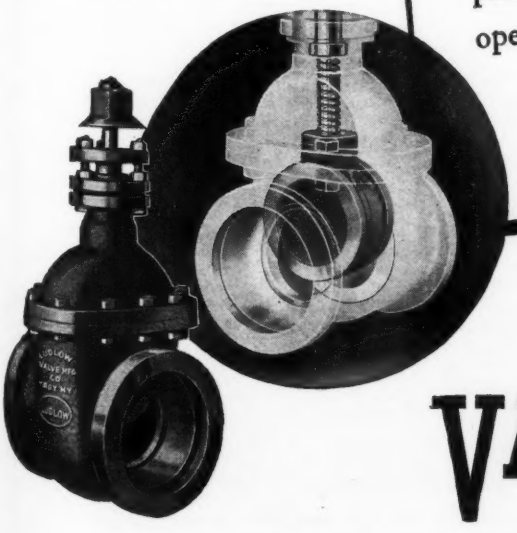

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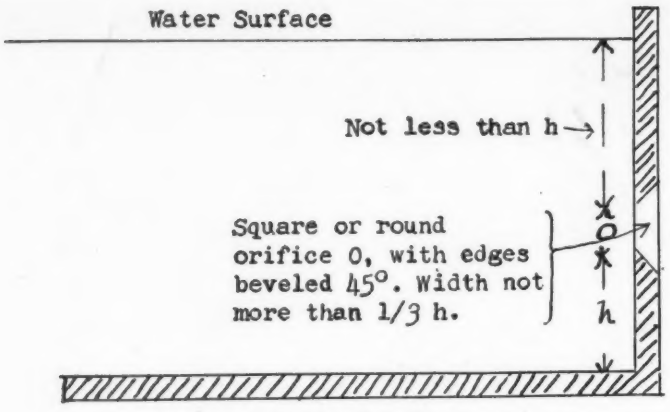

Fig. 14—A standard orifice in a tank.

TABLE IV

Table of Values of A

Size of Orifice	*Value of A*
1″	0.0055
1½″	0.012
2″	0.022
2½″	0.034
3″	0.049
3½″	0.067
4″	0.087
5″	0.136
6″	0.196

TABLE V

Table of Values of B

Pressure in Pounds	*Head in Feet*	*Value of B*
10	23	4.8
15	35	5.9
20	46	6.8
25	58	7.6
30	69	8.3
35	81	9.0
40	92	9.6
45	104	10.2
50	115	10.7

The pressure on the gage is 30 pounds. What is the discharge in gallons per minute?

The formula for discharge is 449 x 5.2 x A x B.

From the tables, A for a 3-inch orifice is 0.049 and B for 30 pounds pressure (equivalent to 69 ft. of head) is 8.3. Then 449 x 5.2 x 0.049 x 8.3 = 943 gpm.

Example 2: A 4-inch pipe discharges through a 2-inch orifice of the type shown in the illustration. The pressure on the gage is 20 pounds. What is the discharge in gallons per minute?

From the tables, A = 0.022 and B = 6.8.

Then 449 x 5.2 x 0.022 x 6.8 = 350 gpm.

If the opening in the orifice is greater or less than ½ the diameter of the pipe the factor of 5.2 in the formula will be greater or less. It is convenient to make the orifice exactly ½ the pipe diameter.

The pressure should be read after the nozzle has been discharging a few minutes—long enough to get an average reading.

(g). Measurement of Discharge Through an Orifice in a Tank.—With relatively small flows and small heads it may be desirable to measure the discharge of a pipe by allowing it to flow into a wooden or concrete box and to measure the discharge by means of an orifice in the side or end of the box, or by means of a weir. The latter is usually better because the shape of the orifice influences considerably the amount of water that will pass through it.

A so-called *standard orifice* is shown in Fig. 14. For accurate measurement, the head *h* on the orifice should be at least 3 times the vertical height of the opening *o* of the orifice and the orifice should be located at least 3 times the least dimension of the orifice from the bottom or any side wall.

For instance, an orifice 3 inches square should be at least 9 inches from the bottom or from either end, and for accurate measurement there should be at least 9 inches of water above the center of the orifice.

The formula for discharge in gallons per minute for orifices under the above description is

$$gpm = 2195 \times A \times B$$

where A is the area of the opening in square feet (see Table D), and B is the square root of the head on the center of the orifice in feet. This formula does not assume any velocity of approach; therefore the tank should be large enough so that the water is held relatively still.

Procedure.—Construct the orifice carefully, according to the drawing herewith. Fasten an accurate rule to the inside of the tank, with its bottom at the elevation of the center of the orifice. Make the tank deep enough so that a head of at least 24 inches is available above the center of the orifice. Construct the orifice 1 inch square for flows of 12 to 25 gpm. Use a 2-inch square orifice for flows of 50 to 100 gpm; and a 3-inch square orifice for flows of 100 to 200 gpm. Flows that are larger than 150 or 200 gpm. are best measured by the pipe orifice method described under f of this section. For flows between 25 and 50 gallons, either a 1½-inch square orifice can be used, or the head increased above 2 ft.

TABLE VI

Size of opening	*Value of A*
1″ square	.007
1½″ square	.016
2″ square	.028
3″ square	.063
4″ square	.111

TABLE VII

Values of B

Inches Head on Orifice	*Value of B*	*Inches Head on Orifice*	*Value of B*
9	.87	17	1.19
10	.91	18	1.22
11	.96	19	1.26
12	1.00	20	1.29
13	1.04	21	1.32
14	1.08	22	1.35
15	1.12	23	1.38
16	1.15	24	1.42

The tank should be allowed to fill until the discharge through the orifice equals the inflow. The level in the tank will then remain constant. Measure the head, as shown by the water surface on the rule.

Example 1. Using an orifice 2 inches square, the level of the tank into which the water is discharging remains uniform at 23 inches above the center of the orifice, what is the discharge into the tank?

Solution: From the formula,

$$gpm = 2195 \times A \times B$$

From the Table VI, for an orifice 2 ins. square, A = 0.028 and from Table VII for a head of 23 ins., B = 1.38. Then

$$gpm = 2195 \times 0.028 \times 1.38 = 85$$

The flow is 85 gallons per minute.

Example 2. Using an orifice 3 ins. square, the level of the tank remains constant at 18½ ins. above the center of the orifice.

Solution: Using the formula above, A = 0.63, from Table D and from the Table for B, the value for 18½ ins. may be taken midway between 18 ins. and 19 ins., or 1.24

$$gpm = 2195 \times 0.063 \times 1.24 = 172$$

and the flow is therefore 172 gpm.

(h). Discharge From Fire Hydrants.—It is often convenient to know the amount of water that is discharged from a fire hydrant. There is more than one way to do this, but the simplest way is to measure

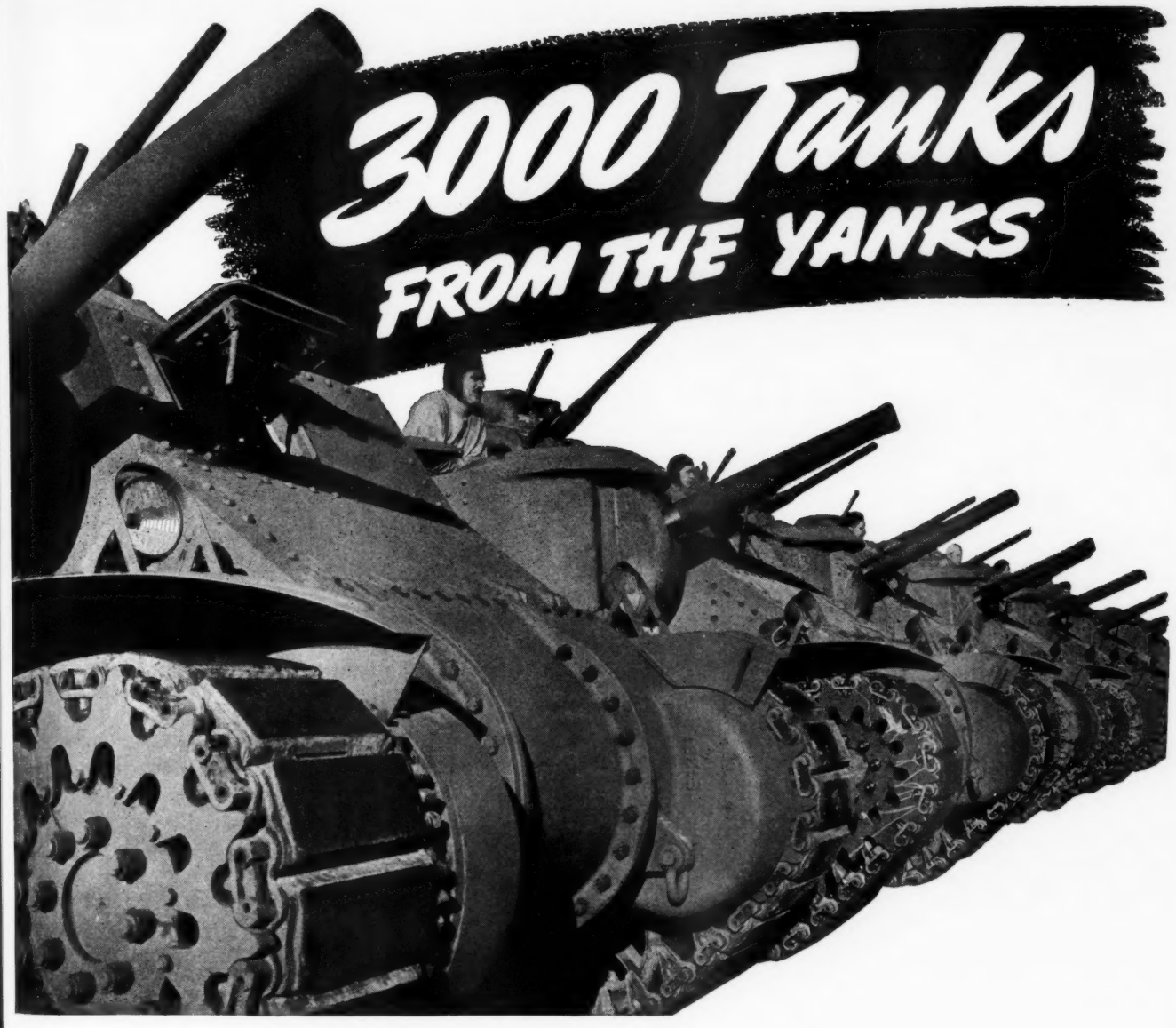

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TABLE VIII

Discharge in Gallons per Minute for Various Pressures and Nozzle Sizes. Inside Nozzle or Connection Sizes in Inches

Pressure, Pounds Per Sq. Inch	2⅜	2½	2⅝	3½	4	4½
½	110	120	130	240	300	370
1	150	170	190	320	440	550
2	210	240	260	460	610	780
3	260	290	320	560	750	950
4	300	340	370	660	860	1100
5	340	380	420	750	960	1220
7	400	450	490	880	1150	1450
9	460	510	560	1000	1300	1650
11	510	560	620	1100	1440	1820
13	550	610	670	1200	1550	1980
15	590	650	720	1280	1670	—
17	630	700	770	1360	1790	—
20	680	750	830	1470	1940	—

carefully the diameter of the inside of the hydrant nozzle or connection. Then tap a pressure gauge into a cap that is threaded to fit on one of the nozzles or connections. Where a hydrant has 3 connections, the flow can be measured from either one or two of them, the pressure gauge being placed on one. (It may be placed on the steamer connection if there is one). The discharge from one or both nozzles can be computed easily from the diameter and the reading of the pressure gauge while the hydrant is flowing. An approximate formula, accurate enough for ordinary purposes, is $27\ d^2\sqrt{p}$, where d is the diameter of the opening in inches. The table above gives readings accurate enough for most purposes. Where the exact pressure is not shown, average the figures for the two nearest readings.

Example 1. A hydrant has 3 nozzles, each 2½ inches internal diameter. A pressure gauge placed on a cap fitting over one of these nozzles registers a pressure of 16 pounds when the other two are discharging fully.

How much water does the hydrant deliver?

Solution. From Table VIII it will be found that a hydrant will discharge 650 gpm through a 2½-inch nozzle with a pressure of 15 pounds and 700 gpm at 17 pounds. The average of the two figures may be taken as the discharge at 16 pounds. Then $\frac{650 + 700}{2} = 675$ gpm that each nozzle will discharge; and the two nozzles will discharge 2 x 675 = 1350 gpm.

The figures in the table are to the nearest 10 gallons. It is useless to attempt greater accuracy.

Example 2. A hydrant having a nozzle opening 2 9/16 in. in diameter discharges under a pressure of 17 pounds. What is the discharge in gallons per minute?

Solution. While there is no discharge shown for a 2 9/16-inch opening, figures are given for 2½ and 2⅝-inch openings. The 2 9/16-inch nozzle discharge will be about midway between the discharge for the next smaller and next larger openings. For 17 pounds pressure, the 2½-inch nozzles, according to Table VIII, dicharges 700 gpm, and the 2⅝-inch nozzle 770 gpm. Therefore the 2 9/16-inch nozzle will discharge about 735 gpm.

Use.—The measurement of discharge from a hydrant is not generally used merely to determine flow, but usually to determine how much water is available for fire protection at any hydrant or in any section of the city. If the average fire hose under a pressure of about 50 pounds discharges 200 gallons per minute, it is easy to determine how many hose lines can be used effectively on a hydrant or group of hydrants.

If the pressures given in the table herewith are lower than those actually found, more hydrants can be opened, thus reducing the pressure so that the table can be used. The total discharge will be the sum of the discharges from all the hydrants.

From the discharge results obtained, and from the pressure drop, additional information of value may be obtained, including the estimated discharge at lower or higher pressures, based on the pressure in the mains before opening the hydrants and the pressure when the hydrants were fully open. The data obtained in this way is not very exact, but may be of value. It is based on the square roots of the pressure drops (see Table IX), that is, $\sqrt{d}$, where d is the drop in pressure. For instance, if the static pressure before opening the hydrant were 61 pounds per sq. inch, and at a drop to 36 pounds the discharge amounted to 1600 gpm, how much would the discharge probably be at a discharge pressure of 25 pounds? The drop in pressure from 61 to 36 pounds was 25 pounds. The square root of 25 is 5. At a pressure of 25 pounds, the pressure drop is 61-25 = 36 pounds and the square root of 36 is 6. The probable flow, if the hydrants were open sufficiently to drop the pressure to 25 pounds, would be

$$\frac{1600 \times \sqrt{36}}{\sqrt{25}} = \frac{1600 \times 6}{5} = 1920 \text{ gpm.}$$

Tables showing square roots and also squares, areas of circles, and much other handy information are available in hydraulic or mathematical handbooks, and also in several of the handbooks issued by manufacturers of water works equipment.

TABLE IX

Square Roots of Pressures

Pressure	*Sq. Root*	*Pressure*	*Sq. Root*	*Pressure*	*Sq. Root*
10	3.2	28	5.3	46	6.8
12	3.5	30	5.5	48	6.9
14	3.7	32	5.7	50	7.1
16	4.0	34	5.8	52	7.2
18	4.2	36	6.0	54	7.3
20	4.5	38	6.2	56	7.5
22	4.7	40	6.3	58	7.6
24	4.9	42	6.5	60	7.7
26	5.1	44	6.6	62	7.9

If the actual pressure drop falls between the figures given in Table IX, average the next higher and next lower results.

Example. The discharge from a hydrant amounts to 900 gpm. The static pressure before opening the hydrant was 70 pounds, and during discharge at 900 gpm was 51 pounds. What is the probable discharge at 35 pounds?

Solution. The pressure drop at 900 gpm was 70 — 51 = 19 lbs. If the pressure is 35 pounds, the drop will be 70 — 35 = 35 pounds. The square root of 19 is about 4.35 $\left(\frac{4.2 + 4.5}{2} = 4.35\right)$ and of 35 is 5.9 $\left(\frac{5.8 + 6.0}{2} = 5.9\right)$. Then the discharge at 35 pounds pressure will be about 900 x 5.9 ÷ 4.35 = 1220 gpm.

i. Measurement of Flow by the Use of Weirs.—(1). The term "weir" is often used to designate a dam, usually a particular type of low dam, and from this

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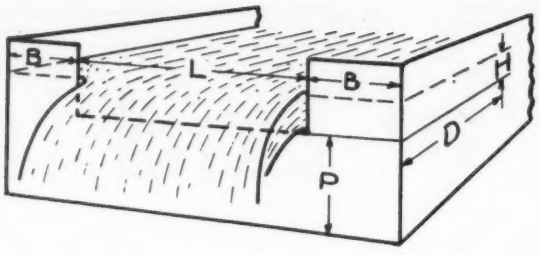

A = water cross-section in channel, sq. ft.
L = 3H or more. P = 2.5H or more.
B = 2.5H or more. D = 2.5H or more.

Fig. 15—Weir with end contractions.

loose use of the term has been derived an exact meaning of the word "weir" when used as a measuring device. The weir, when considered as a measuring device, is a notch or opening in the top of a vertical dam through which the water flows. Many experiments have been made to determine how much water will flow over a weir with a given head or depth of flow, since weirs are often the cheapest and also may be the only method available for the accurate measurement of flow of a stream.

Slight changes in the construction of a weir will result in considerable variations in the amount of water passing over it. Therefore care must be used to construct weirs properly.

(2). The waterway of weirs may be rectangular, triangular, or trapezoidal. Weirs are of two general types—with and without end contractions. In a weir with end contractions, the notch over which the water passes is narrower and shallower than the channel of the stream or the flume carrying the water. In a weir that does not have end contractions, the overflow notch is as wide as the channel leading to it. Such a weir is sometimes called a suppressed weir.

In the weir with end contractions, Fig. 15, the formulas for flow are based on having the distances B from the ends of the notch to the corresponding side walls of the flume or channel at least three times as great as the depth H of the water passing over the weir. Also the length of the weir crest L should be about 3 times H; the depth of the box or dam below the crest of the weir P should be at least 2½ H and the distance back from the weir D at which the head H is measured should be 3H or not less than 3 ft.

In the suppressed weir (that is, one without end contractions) the sides should be smooth and straight and should project slightly beyond the bottom of the notch. Some arrangement must be provided for admitting air under the water passing over the weir, or the discharge rate will be increased and the formula for this type of weir will not be accurate.

The edge of the weir over which the water flows is called the crest. The inner or upstream edge of the crest is always made sharp, as with a chisel edge, so that the water in passing over touches only a thin edge or line. For usual work, it is sufficient to cut off the board so as to make an angle with the vertical (when the weir is in place) of about 30°. This is accomplished by measuring back from the edge to be beveled twice the thickness of the board. The beveling should be straight and the resulting edge thin, true, straight and level. The sides of the weir must be set square with the crest. To obtain accurate measurements, accurate and careful work is necessary.

(3). Requirements for Weir Measurements.—In summary, for accurate measurement weirs should meet the following requirements: (1) The weir must be placed perpendicular to the direction of flow and it must be vertical; (2) The crest should be sharp—not over 1/16 inch wide—smooth and level; (3) The surface of the water downstream must be lower than the crest of the weir; (4) It must be possible for air to enter beneath the sheet of water falling over the weir; (5) The channel of approach to the weir must be straight and unobstructed; (6) A depth of flow over the weir of 0.2 ft. to 2.0 is desirable for accurate measurement. Therefore the weir should be sufficiently long or wide to maintain the depth of flow between these ranges.

In regard to (3) above, the bottom of the channel, when weirs with end contractions are used, should be about 2 ½ H (2½ times the depth of flow over the crest) below the crest.

(4). Head on the Weir.—The head or depth of flow over a weir is measured upstream from the crest of the weir. This is necessary because the water, as it approaches the edge of the weir, curves downward, and the depth measured at the crest would be less than the actual head. With a level, set a rule or gauge with its bottom or zero at the elevation of the crest, placing the rule 3 or 4 feet or more back from the weir. Then

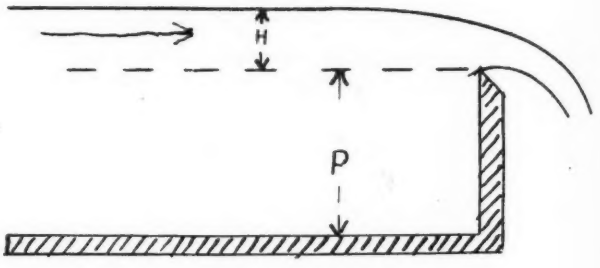

Fig. 16—Section of a standard weir.

the head or depth of flow can be read directly from the gauge or ruler.

(5). Factors Influencing Flow.—The factors influencing the amount of flow over a suppressed weir that has been properly constructed as already described are (1) the width or length of the notch; and (2) the depth or head of flow over the crest. In regard to the length of the notch or opening, the amount of flow is almost exactly dependent upon the length. If all other conditions are the same, a weir 4 ft. long will discharge almost exactly four times as much as a weir that has a length of 1 ft.

As the head or depth of flow over the crest increases, however, the volume of flow increases still more rapidly. Thus, a weir 1 foot wide may discharge approximately 1.2 cubic ft. per second when the depth of flow over it is 6 inches; but, with a depth of flow of 12 inches, the discharge will be approximately 3.34 cfs.; and with a depth of flow over the crest of 18 inches it will discharge about 6.1 cfs. Therefore, careful measurement of the actual depth of flow over a weir is necessary.

(6). Accuracy of Measurements.—Under field conditions, measurements of flow over a weir may be expected to be in error by as much as 5%, even when the weir is constructed carefully. As already pointed out, this degree of accuracy is generally sufficient for most hydraulic computations.

(7). Flow Over Weir Without End Contractions.—

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- Water Softeners
- Zeolites

The table below gives the volume of flow over a weir 1 ft. long, as computed by the Francis formula, for varying heads or depths of flow over the crest. Although it is desirable to have a minimum head or depth of flow over the crest of about 2½ inches, approximate flows for lesser heads are given. To obtain flows over longer weirs, multiply by the length of the weir in feet.

TABLE X

Discharge Over Weirs 12" Long for Varying Heads

Head or depth of flow over the weir	*Discharge in gallons per minute*	*Head or depth of flow over the weir*	*Discharge in gallons per minute*
½ inch	12	4¼ inch	316
¾ "	22	4½ "	344
1 "	34	4¾ "	373
1¼ "	47	5 "	402
1½ "	62	5½ "	466
1¾ "	74	6 "	530
2 "	101	6½ "	595
2¼ "	124	7 "	665
2½ "	142	7½ "	739
2¾ "	164	8 "	815
3 "	187	8½ "	893
3¼ "	211	9 "	980
3½ "	236	10 "	1145
3¾ "	261	11 "	1318
4 "	287	12 "	1500

(8) Example (a). A weir without end contractions is 24 inches long and the head H, or depth of flow over the crest is 5¼ inches. How much water is passing over the weir in gallons per minute?

Solution. The flow per foot of length of weir for a head H of 5 ins. is from the Table 402 gpm; for 5½ ins. it is 466 gpm. Therefore, for 5¼ ins., it will be approximately 402 + 466 ÷ 2 = 434 gallons per minute; and for a weir 2 feet long it will be 2 x 434 = 868 gpm.

Example (b). A weir without end contractions is 30 ins. long. The head H or depth of flow over the crest is 7⅛ inches. What is the discharge in gallons per day?

Solution. From the table, the discharge over a weir 1 ft. long for a head of 7 ins. is 665 gpm. For 7½ ins. it is 739 gpm. The difference due to ½ in. or 4/8 is 739 — 665 = 74 gallons. The approximate difference for each ⅛ inch is 74 ÷ 4 = 18½. Therefore the discharge for a H of 7⅛ ins. will be about 739 + 18 = 757 gpm per foot of length. For a weir 30 ins. or 2½ feet long, the discharge will be 757 x 2½ = 1892 gpm. Since 700 gpm equals approximately 1 mgd, 1892 ÷ 700 = 2.7 mgd.

(9). Flow Over Weir With End Contractions.—The flow over a weir with end contractions is affected to some extent by the contractions at the ends. On a long weir, and especially when the head over the weir crest is not great, the effect is of little importance. It has been found that the contraction of the flow affects the discharge to the same extent as if the length of the weir were reduced by 0.2 of the head over the weir. In practice this means that where the head over the weir is more than about one-twentieth of the length of the crest, an allowance should be made for the contractions.

For a weir with end contractions, therefore, assume the length of the weir is reduced by 0.2 of the H and use the table already given for weirs without end contractions.

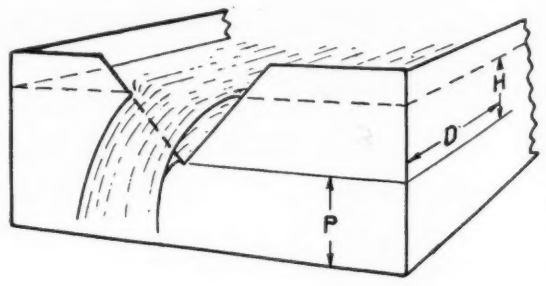
Example. A weir 3 ft. long with end contractions, has a flow head of 12 inches over the crest. What is the discharge in gallons per minute?

Solution. From Table X, for a weir without end contractions, and 1 ft. long, the discharge with 12 ins. H is 1500 gpm. Because of the end contractions, the effective length is reduced by 1/5 or 0.2 H = 0.2 ft. Therefore the effective length is 3 — 0.2 = 2.8 ft. The discharge for 1 ft. length is 1500 gpm. For 2.8 feet it is 4200 gpm. Ans.

In the "Cippoletti" weir the effect of the end contractions is compensated for by giving the ends of the weir a slope of about 4:1, in which case the discharge is approximately the same as for a suppressed weir with an equal length of crest. In a "Sutro" weir the ends have the form of arcs that so contract the width of the sheet of water flowing over it as the head increases, that the volume of flow is directly proportional to the head.

(j). V-Notch Weirs.—(1) General.—The rectangular weir is not well suited for measuring small flows, as will be noted by reference to the discharges shown in Table X. With such weirs a depth of 2 ins. over the weir crest gives a flow for a weir 1 ft. long, of 101 gallons. A greater range of capacities, and greater accuracy with small flows are obtained with a triangular or 90° V-notch weir. Such a weir is shown in Fig. 17. To obtain accurate results, the sides of the channel or the contractions should be set well back; the weir should be exactly perpendicular or at right angle to the flow; the weir should be set in a straight channel; the bottom of the notch should be exactly 90°; the edges should be straight and beveled, as previously described for rectangular weirs; the depth of the channel below the notch of the weir should be at least as great as the maximum head over the notch of the weir. As with the rectangular weir, the head should be measured 3 or 4 or more feet upstream in order to avoid a false reading due to the slope of the water near the weir.

(2) Flow Over a V-Notch Weir.—There are several formulas for flow over a V-notch weir; most of these



P = H or more. D = 5H or more.

Fig. 17—A V-notch weir.

give approximately the same results. The King formula is Discharge in gallons per minute = 1131.5 x $H^{2.47}$ where H is the head in feet of flow over the notch of the weir.

TABLE XI

Discharge Over Triangular Notch Weirs

Head in Inches over 90° Triangular notch weir	*Flow in GPM*	*Head in Inches over 90° Triangular notch weir*	*Flow in GPM*
1¼ inch	4.2	5½ inch	165
1½ "	6.6	6 "	204
1¾ "	9.8	6½ "	249
2 "	13.6	7 "	299
2¼ "	18	7½ "	355
2½ "	23.5	8 "	416
2¾ "	30	8½ "	485
3 "	37	9 "	556
3¼ "	45	9½ "	635
3½ "	54	10 "	721
3¾ "	64	10½ "	813
4 "	75	11 "	913
4½ "	100	11½ "	1020
5 "	130	12 "	1131

(3) Example. A standard triangular or V-notch weir flows with a head, indicated by a gauge 4 feet back from the crest, of 4½ inches. What is the rate of overflow in gallons per minute?

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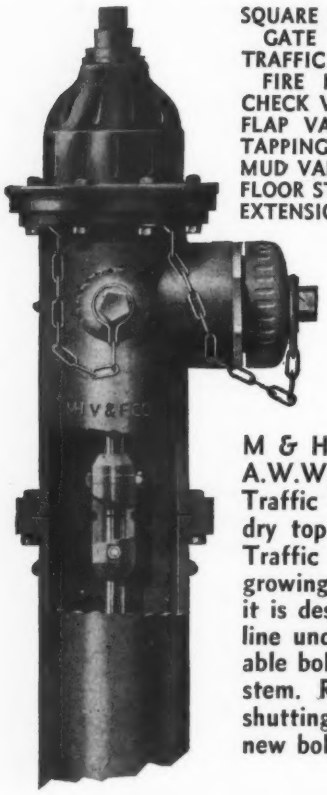

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Solution. From the Table, a head of 4½ inches shows that the flow is 100 gallons per minute.

Example. The head over a standard V-notch weir, measured by a gauge well back from the weir crest, is 8⅜ inches. What is the flow in gallons per minute?

Solution. From the table, the flow for 8 inches of head is shown to be 416 gpm., and for 8½ inches 485 gpm. The ½ inch difference indicates an increased flow of 485 — 416 = 69 gpm; ½ inch = 4/8 ins., therefore ⅜ ins. is ¾ of ½ inch, and the flow when the head is 8⅜ inches will be 416 gpm plus ¾ of 69 gpm; ¾ of 69 gpm is approximately 52 gpm. Therefore the flow with 8⅜ ins. is 416 + 52 = 468 gpm.

Obtaining Water From Government Lake During a Drought

(Continued from page 26)

Our connection to this 7000-acre lake means that we will not be forced to restrict the usage of water in our city again and that we will be able to supply plenty for industrial use. The Railroad and Tieplant, two of our largest industries, had to get their water from Big Muddy River, 4 miles north of the city, from July 10 until this connection was made.

The cost of the Lake Crab Orchard project was as follows:

Cost of Lake Crab Orchard Project

DIRECT COSTS			
Construction supplies and expenses		$ 623.20	
Cast-iron pipe and fittings		40,114.50	
Trenching, joints, etc.		15,668.36	
Clearing		2,300.70	
Right-of-way, easements, land		950.25	
Pump house-building	$1,373.83		
Equipment	2,264.37	3,638.20	$63,295.21
INDIRECT COSTS AND OVERHEAD			
Lease		$ 100.00	
Bond election, printing, etc.		626.24	
Legal fees		1,950.00	
Engineering fees		3,900.00	6,576.24
			$69,871.45

Improvised Sewage Treatment Plant at an Army Camp

(Continued from page 17)

There is one other feature which I feel should be noted before concluding. This is the arrangement in the concrete flumes conveying the flow from DC-1 to the primary clarifier inlet manholes. The passage in each is baffled in an identical manner as the discharge section of the wood flume and for a like purpose, namely, to accelerate the intermingling of the lime and to aerate. As these baffles are of wood (resin-bonded plywood, treated with a penetrative sealer and then painted with bitumastic), they may readily be removed when no longer deemed necessary or if, perchance, they should interfere appreciably with the hydraulic relationship set up between the water level in the PC's and the setting of the comminutor.

The architect-engineer of the plant was The J. R. Worcester Co. The author, as an associate of that firm, was the engineer for design; and has also supervised construction throughout and has further been retained, by the army directly, to place the plant in full operation and to supervise its operation indefinitely.

At latest reports the plant was successfully handling flows considerably above the designated capacity and delivering a decent effluent. Before the next big influx of men we expect to have the whole plant in operation, including the digesters.

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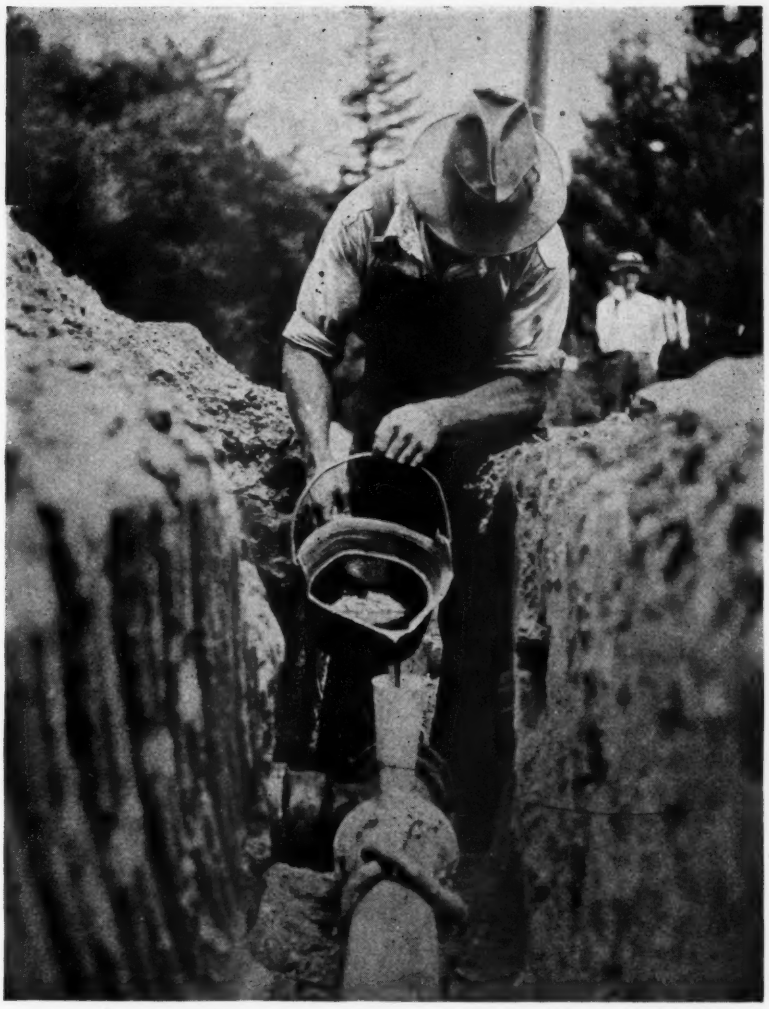

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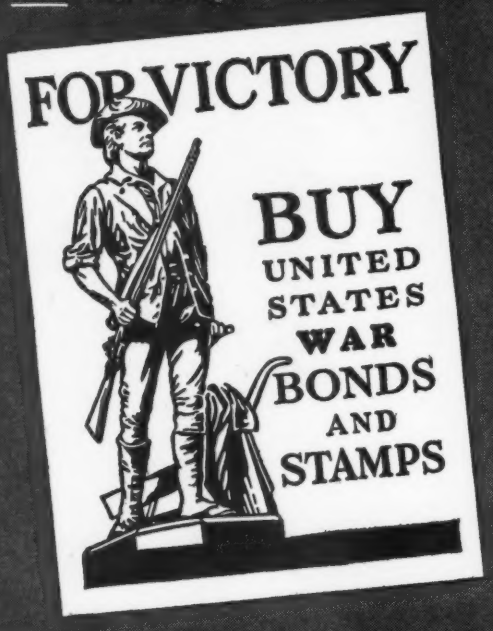

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Lubrication of Machinery in Water and Sewage Treatment Plants

(Continued from page 25)

grease for the motor. For the gear reducer, they recommend varying the oil according to three temperature ranges of atmosphere—below 32°F., from 32° to 70°, and above 70°. For these three ranges, use oil as follows: Socony "Arctic" oil, light for cold, DTE heavy medium for 32° to 70°, and DTE extra heavy for above 70°; or Standard Oil of Indiana "Iso-Vis D, SAE 10 W for below 32°, 20 W for 32° to 70° and 30 W for above 70°; or S. O. Co. of La., N. J., or Pa. "Zerice" No. 37, "Teresso" No. 52 and "Teresso" No. 65 respectively, for the three ranges; or Sun Oil Co. "Solnus" light, medium and heavy; or Texaco SAE 10, 20 and 30; or Gulf "Mechanicoil" B, "Harmony" oil C and "Harmony" oil E; or Pure Oil Co. "Klondyke" light, "Klondyke" med. hvy., and Puroco hvy.

(To be continued next month)

Siphon Principles in Culvert Design

(Continued from page 24)

extended without benefit of an hydraulic analysis of the effect on stage and capacity.

3. Culvert designers should be familiar with the true siphon as an economical drainage device and as a factor affecting estimates of discharge through existing culverts.

4. Standard culverts may be laid on down-broken grades to save excavation costs with assurance that siphoning will partly offset the impairment of grade. Particularly, the critical design stages may be unchanged by the impairment.

5. Flare-siphon culverts can be designed hydraulically by the formulae presented herein.

6. Flare-siphons offer great promise in the solution of cross drainage problems in broad valleys, particularly (a) if moderate stages will cause damage; (b) if roadway grade is low and likely to be overtopped; (c) if existing culverts on narrow roads are to be extended.

Scrap in England

By getting in "all available scrap iron," the English mean just that. The recreation grounds of Lansing Parish were surrounded by a fence that contained 18,700 lbs. of iron. This was requisitioned for munitions and the parish was allowed about $50 for it; which rather peeved them, for they have not yet finished paying the $3,500 that it cost them.

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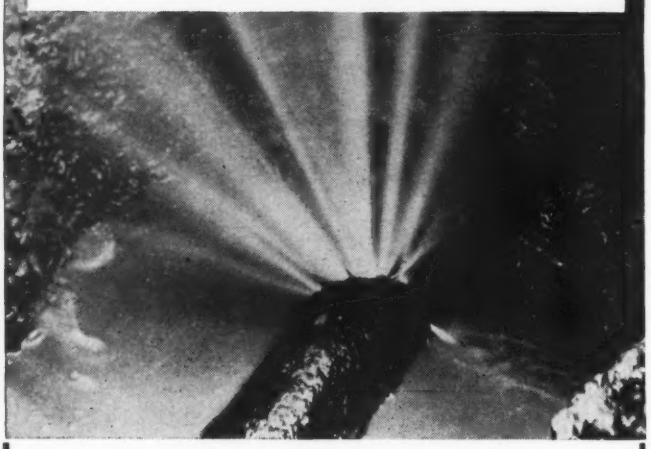

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THE PITOMETER COMPANY

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gated and deposited in bins, washed and graded ready to be returned to the filter.

Then the cast-iron laterals were removed from the filter and sand-blasted inside and out. The reinforced concrete filter walls, floors, wash-water troughs, etc. were cleaned and brushed down by means of heavy wire brushes; after which a 1/32 inch layer of "No-Oxid" XX waterproof coating was applied by means of a spray gun and smoothed to a glossy finish by the flame of a weed-burning torch.

The cast-iron laterals, after being sand-blasted, were rust-proofed by dipping in a horizontal tank about two-thirds full of "No-Oxid" XX, which was maintained at a heat of about 250° by means of a gas burner. After staying in this tank for about two minutes the laterals were drained for about two minutes and placed on a drying rack. After drying on this for about five minutes they were ready to be replaced in the filter. Originally the laterals had been fastened into place in the manifold by means of lead joints, about 400 pounds of lead being used in each filter. In replacing the laterals, the joints were made with cement and thus about 2800 pounds of lead was salvaged.

The cleaned and graded gravel and sand then were replaced and the filter sterilized approximately three days before being placed back in service. In three of the seven filters anthrafilt was substituted for the original sand.

In renovating the operating tables, the 4-way valves were re-bushed and lubricated. All hydraulic valves were removed, cleaned, repaired, rust-proofed with "No-Oxid" A-Special, and returned to place.

The above is abstracted from a paper by Paul Weir, assistant general manager of the Atlanta Water Department, before the Eleventh Georgia Water and Sewage School.

Water Storage as an Air Raid Precaution

English cities provide for fighting fires, after air raids that have destroyed mains, by storing water in basins scattered throughout the city. The basins provided in Leeds were described in a paper read in September, 1942, by W. Sleight, the chief engineering assistant of that city, of which the following is an abstract.

There are two general classes of construction—basins with a capacity of over 33,000 gal., and tanks of 5,000 to 22,000 gal. capacity. Four general types of basins were standardized: (1) Dished type with sett-paved lining and wholly sunken. (2) Dished type, with concrete lining and wholly sunken. (3) Circular brick type, with concrete or sett-paved base, either wholly or partly sunken. (4) Brick-concrete surface type.

The type adopted for any particular site depends primarily upon the size of site and surface levels; water required, which determines size of basin; bearing capacity of the subsoil; and type of labor and materials of construction available. Test holes were excavated at each site to determine the soil formation.

Where basins were constructed in built-up areas, the wholly sunken type was adopted if possible to minimize danger of flooding basement shelters if the basin were damaged. Where semi-sunken types had to be used, protective banks were constructed around the basin above the ground level on the low side.

Dished basins, of 250,000 to 500,000 gal. capacity, were made with a water depth of 6 to 8 ft. and side

slopes of 3:1, in some cases reduced to 2:1 above water level. Most of them were lined with setts (stone blocks) that had been removed from the pavements of several streets that had been abandoned. These were about 6″ deep and were bedded in 2″ of sand (later changed to 4:1 sand-cement) with ⅜ in. joints. The bottom 4″ of the joint was filled with pitch and the top 2″ with 2:1 cement grout. On completion, the whole interior surface was hot sprayed with a bitumen product and covered with limestone dust. On filling one basin, slight local settlements occurred and the whole basin was lined with ¾ in. of rock asphalt.

Where concrete lining was used it was made of slabs 6″ thick and 21 by 14 ft. area, laid in alternate blocks, using a 4:2:1 mix, and well tamped. Reinforcement was used, two layers at points where reverse bending stresses might develop. At first a concrete beam 18″ wide by 9″ deep was placed under each joint and covered with a layer of bitumastic felt 18″ wide by ¼″ thick, but this was omitted in later construction. The joints between slabs were made in two parts, the lower 4″ being filled with ¼″ expansion joint material, and the top 2″ being made as a dovetail joint, which was filled with poured bitumen.

Circular basins were constructed where there was considerable cross-fall, the excavated material being used to form a bank not less than 30 ft. wide on the low side. The walls were of concrete between 4½-in. inner and outer brick walls, the overall thickness varying from 30 in. at the base to 14 in. at the top. The brick walls served as forms, in which the concrete was placed and rammed in 12 in. layers. No reinforcement was used, but earth was rammed around the outside and brick headers extended into the concrete at 3 ft. intervals. The floors were of the concrete construction described above, with an asphalt dovetail joint between floor and wall.

The tanks used were of four types: 5,000 gal. rectangular steel tanks; circular steel with concrete bottoms; rectangular tanks with solid brick walls 4 ft. high, 2 ft. thick at the base and 9″ at the top, with concrete floor; and of the concrete-brick type used for circular basins but with reinforcing fabric which tied the wall to the bottom and took tension stress at the bottom of the wall.

Using Power Patrols in Tandem for Heavy Grading

(Continued from page 13)

When we are through we should have a road bed a foot or so higher than the adjoining fields, ditches that will drain, and a well settled road ready for gravel at the rate of 800 to 1000 cu. yds. per mile. Better put the gravel on in two coats with a packing time in between; let the traffic do the packing.

A five-foot cut is about the maximum in this county, although we have cut down some sizable hills where the end haul was not too long, and have made many round corners with these tools and methods.

We have no advertising, no blueprints, no contractor, no bond, no labor troubles—and of course not much road. But when the "bottle-neck" is removed, the good road on each side of it makes quite a stretch. Charge it all to "Maintenance."

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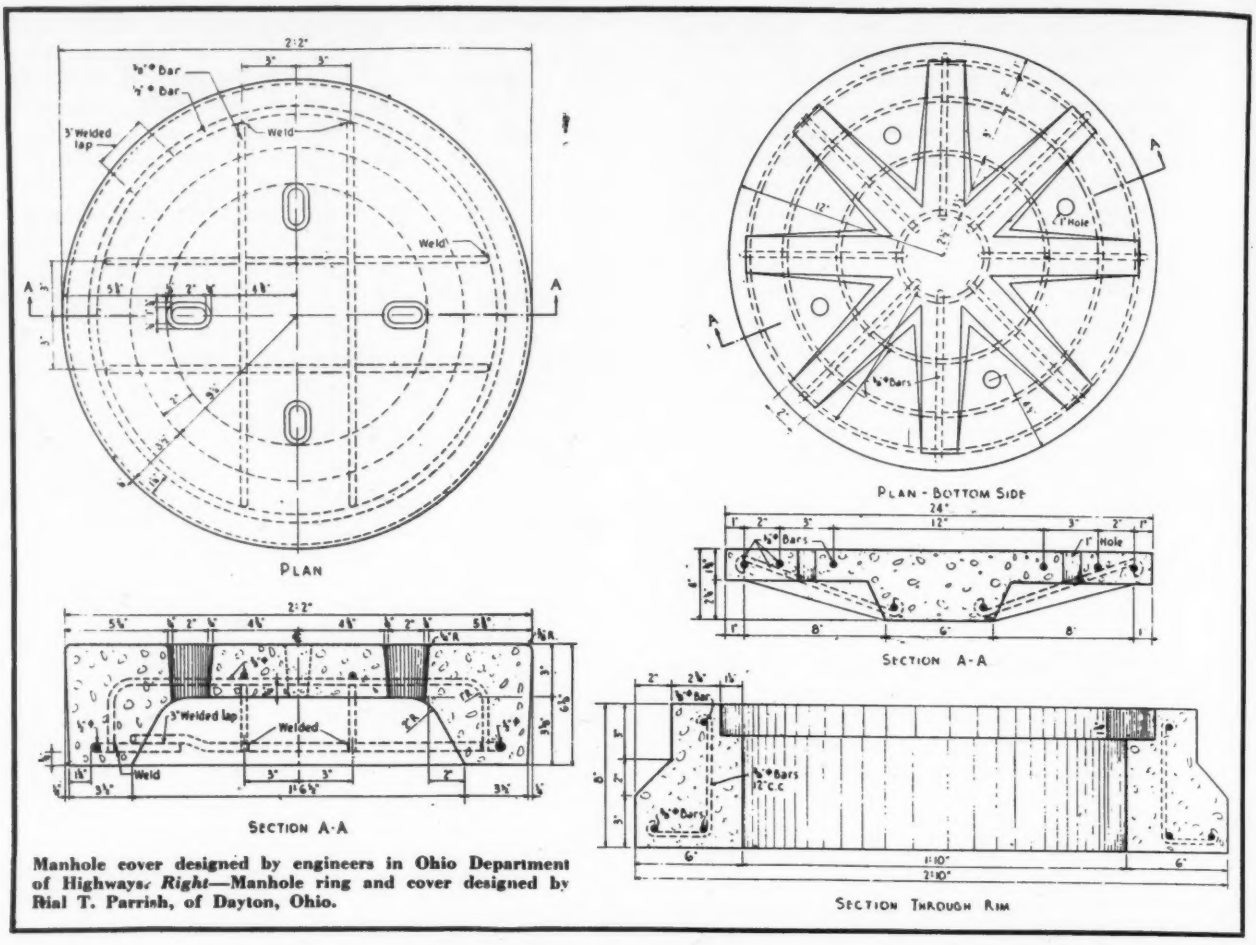

Manhole cover designed by engineers in Ohio Department of Highways. *Right*—Manhole ring and cover designed by Rial T. Parrish, of Dayton, Ohio.

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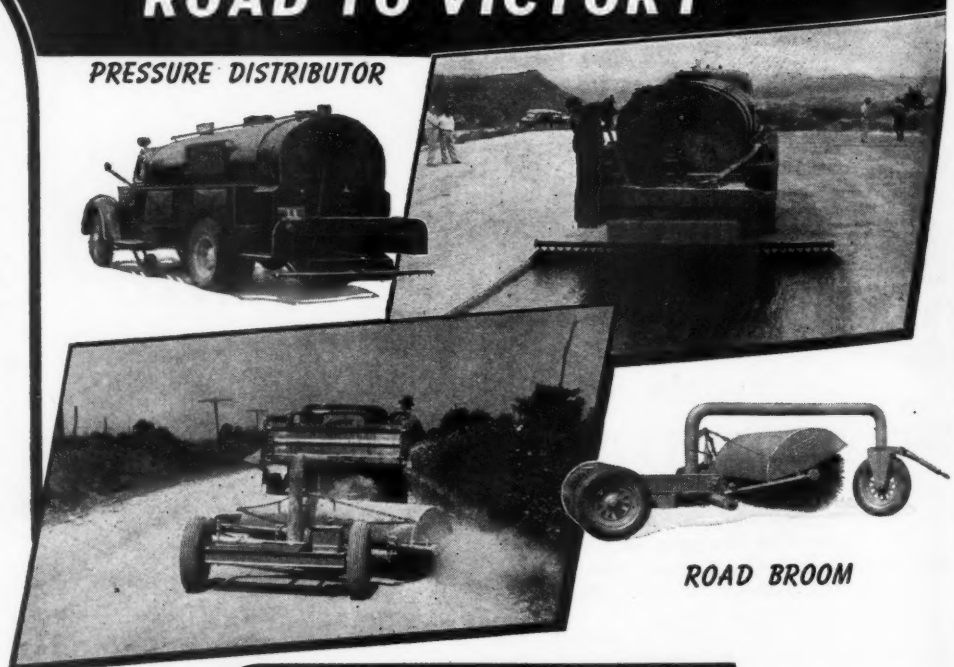

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Concrete Manhole Covers for Ohio Highways

CONCRETE manhole covers and frames, designed by the Ohio Department of Highways, were recently installed in new highway paving adjacent to an aeronautical plant.

The manhole cover, which requires but about 8½ lb. of reinforcement, is 13 in. in diameter, 3 in. thick in the center section, which is surrounded by an outer ring 6⅞ in. deep tapered from a thickness of 5½ in. to 3½ in., and with a ¼-in. camber inward from the top to insure a snug fit. Reinforcement consists of 4 bars placed 3 in. each side of the rectangular axis and bent down on a 1-in. radius to within ¾ in. of the bottom of the cover legs. These bars are welded to a circular ½-in. bar set with its outer edge 1¼ in. in from the outside face of the cover. Four handholes are cast on the rectangular axis with centers 6 in. from the center of the cover. Covers are cast of Class "C" concrete.

The cover frame, or that portion blocked out of the pavement surrounding the cover, usually 4 ft. square, is of the same concrete as the pavement.

Covers were made by WPA and have been installed on a completed section of U. S. 25, near Cincinnati, as well as on State Highway 982 near the war production plant mentioned above.

At the latter location the concrete in the manhole covers was made the same color as the colored concrete that formed the separation strip in the new divided highway. This concrete was treated with red oxide of iron as a device to improve traffic control.

Another design of concrete manhole cover, which includes a ring, was designed by Rial T. Parrish, architect and engineer, of Dayton, Ohio, and is being used at an army airfield in Ohio.

This cover is 24 in. in diameter and 1¾ in. thick at the perimeter. Eight stiffening ribs increase this edge thickness to 4 in. at the centers. Reinforcement consists of 4 concentric ⅜-in. round rods set in the middle of the minimum thickness slab at distances 1, 2 and 3 in. from the perimeter of the cover. A fourth concentric rod is set 2½ in. from the cover center and ¾ in. in from the underface of the thickened central area.

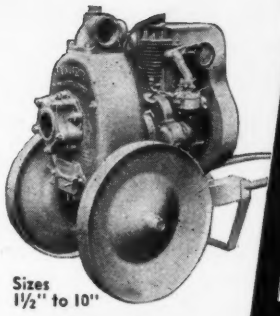
This manhole is used with a reinforced concrete ring of 2-ft. 10-in. outside diameter and 1-ft. 10-in. inside diameter, with a 1¼x1¾-in. shoulder into which the manhole cover fits. The ring is reinforced with three ⅜-in. circular bars and 7 hook bars.

The total weight of reinforcing per cover is about 8½ lb. Ring reinforcing is 10½ lb., making total reinforcement weight for ring and cover only about 19 lb. This is a much smaller amount of metal than would be required for a similar design of cast iron.

From *Concrete Highways.*

More Highway Projects Ordered Stopped

Thirteen highway construction projects having an estimated total cost of $2,011,283 were ordered stopped by the War Production Board on April 26. Five of these (2 are bridges only) are in Missouri; one road in each of the states of Louisiana, Massachusetts, Nevada, Oregon and Colorado; bridges on two highways in Montana, and a flash-light railroad crossing signal in Louisiana.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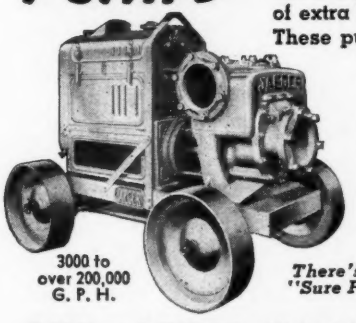
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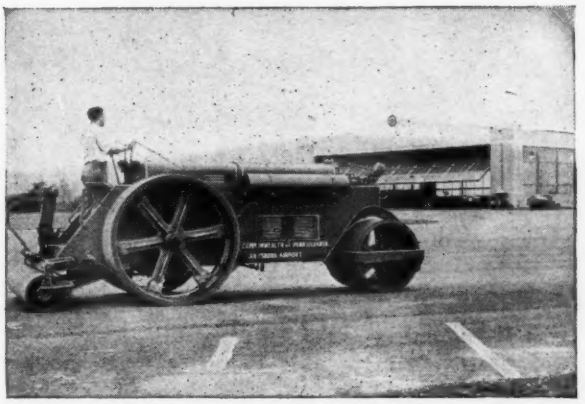

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Methods and Efficiency of Disinfecting Jute Packing

(Continued from page 18)

Summary of Results.—1. The best method of disinfection was that of autoclaving. Twenty minutes, at 121° C. and 15-lb. pressure, were adequate.

2. Soaking in a solution containing 200 ppm chlorine was the next best method.

3. Soaking in boiling water is not believed practicable. The jute has a tendency to disintegrate upon being placed in boiling water.

4. Dry heat is not believed a practicable method of disinfection, since the fibers become brittle when adequate temperatures are reached.

5. Because of the high bacterial content of the jute, one gram of the material serves as a satisfactory sample for tests of this nature. (All tests were made on 1-gram samples.)

No tests were made on the caustic lime method, whereby the jute is stored in a container with lime and removed only as used.

Army Builds Creosoted Timber Bridges

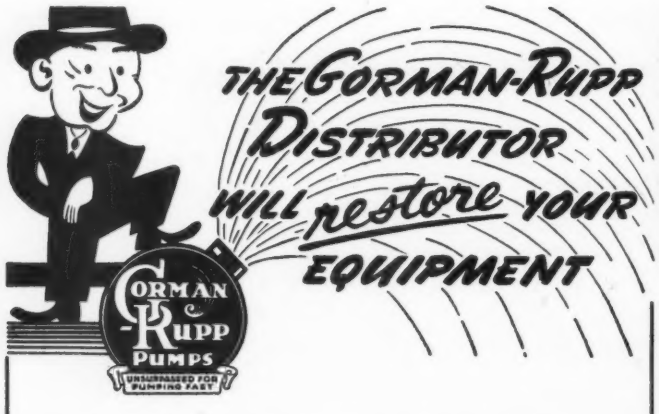
(Continued from page 19)

Both roadway and sidewalk trusses are 60-ft. spans with eight 7½-ft. panels and parallel chords. The use of Teco ring connectors made practical timber web members and economical chord splices. For the vehicular trusses the top chords and end posts consist of four lines of 4 x 10-in plank and the bottom chords of four lines of 4 x 8-in. plank. Each vertical has five lines of 4 x 8-in. plank. Diagonals generally contain two lines of plank decreasing in size from 3 x 12 in. at the second panels to 2 x 8 in. at mid-span.

The sidewalk trusses are double lines of plank, 3 x 10 in. in the top and 3 x 8 in. in the bottom chord. Each diagonal contains two lines of timber decreasing from 3 x 10 in. in the second panels to 3 x 8 in. through the center. The verticals throughout are single 4 x 8-in. plank.

The floor beams are deck trusses with an effective height of 4 ft. There are six 4-ft. 8-in. panels under the vehicular roadway and two 4-ft. panels under the sidewalks. Chords are made up of two lines of 3-in. plank separated by 8-in. verticals conforming in width with those in the roadway and sidewalk trusses. For upper chords, 12-in. depths of plank were used, and for the lower chords, 10-in. depths. Each diagonal consists of two plank decreasing in size, from 3 x 14 in. in the panels adjacent to the roadway trusses to 2 x 10 in. at the roadway centerline and to 3 x 8 in. under the sidewalks.

Trestle spans are uniformly 17 ft. center to center of bents. The vehicular roadway is supported by 15 lines of 6 x 14-in. stringers, and sidewalks are supported on 3 lines of the same size stringers. Outside stringers are butt jointed over the cap centers; all others are lapped at the bents to provide full cap bearing. Handrails have a height of 3½ ft. above the deck level. Where sidewalks are omitted and the rail is adjacent to the vehicular roadway, there is a single 6 x 6-in. longitudinal rail centered 6 in. below the top of the post into which it is dapped 2½ in. Rail posts are 8 x 8 in. in



As more materials are diverted to essential war uses, new equipment becomes more difficult to get. Greater care must be given present equipment until after Victory. Let your Gorman-Rupp distributor restore your equipment to its original operating efficiency. They carry parts and repairs for all equipment they sell. Their charges will be reasonable.

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KOEHRING COMPANY
Milwaukee, Wisconsin

MUD-JACK METHOD

size and are spaced on 5-ft. 8-in. centers. Where sidewalks are provided, rails are of the same height as those on bridges without walks, but posts are 6 x 6 in., and there are three longitudinal rail members, the lower 3 x 6 in. in size constituting a curb at the outer edge of the walk. A 2 x 4-in. plank is placed at mid-height and a 2 x 6-in. near the post top. Curbs at the edges of the vehicular roadway are 12 x 12-in. timbers resting on 3 x 12-in. x 4-ft. 8-in. scupper blocks.

Laminated decks are used on both trestle and truss spans. Trestle decking is 3 x 6-in. plank on edge normal to traffic. Random lengths were permitted to facilitate procurement. On the truss spans, decking is 3 x 8-in. plank on edge running longitudinally. Lengths are multiples of panel lengths, so that splices occur over a support. Scupper blocks rest on a 3 x 16-in. continuous plank spiked to the laminated deck for a surface retainer.

Substructures throughout are creosoted pile bents. Double bents were driven for the truss abutments, with the two parallel rows of piles 3 ft. apart. The piles are arranged to provide a 4-pile group with spacing of 3 ft. in each direction centered under the ends of both roadway and sidewalk trusses. Between truss bearings spacing is approximately 8½ ft. Truss abutments have 20 piles for spans with sidewalks and 12 for those without. In addition, in each case a nose pile is driven upstream. Abutments are sheathed with 3 x 8-in. horizontal planking on 12-in. centers from cap level to below low water, the sheathing at the ends beveling into the nose pile to form a V-shape cutwater. Cap level, which is the under side of the lower chords, is 5 ft. below the tops of the floor beams, and deck ends at the abutments are carried on pony bents erected on the abutment caps.

Intermediate bents for the trestle spans consist of four piles for structures without sidewalks and six for those with them. Bracing is 3 x 10-in. plank. Six-pile bents are really two 3-pile bents side by side, as bracing extends only across the outside three piles. End bents contain seven vertical piles under the roadway section, adding two on each side where sidewalks are supported. In addition, each wing-wall is supported by three piles. Sheathing is 3-in. plank laid horizontally and battened with 1 x 4-in. strips to form tight joints.

Caps are 12 x 12-in. timbers, and, because of the roadway widths, splices were permitted over a pile to utilize readily obtainable lengths.

Dense Structural Square Edge and Sound grade of shortleaf southern pine was specified, and all truss material was surfaced four sides. Piles were also southern pine and varied in length from 30 ft. at the abutments to 55 ft. at some of the center piers, conforming generally to specifications for Class B piles of the American Society for Testing Materials. Approximately 1,600,000 bd. ft. of lumber and 60,000 lin. ft. of piles were required for the project.

All piles and timber except the handrail were pressure treated in accordance with standard specifications of the American Wood-Preservers' Association with 8 lbs. of creosote per cubic foot. Since the project has a life expectancy of only about five years, the 8-lb. treatment, although less than is usually recommended for permanent structures, was specified.

Designs for all the bridges were prepared by Chas. T. Main, Inc., of Boston. Construction was supervised by the Corps of Engineers, U. S. War Department.

The above article is reproduced by courtesy of "Wood Preserving News."

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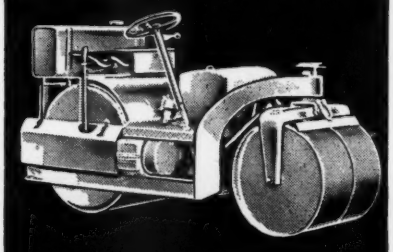
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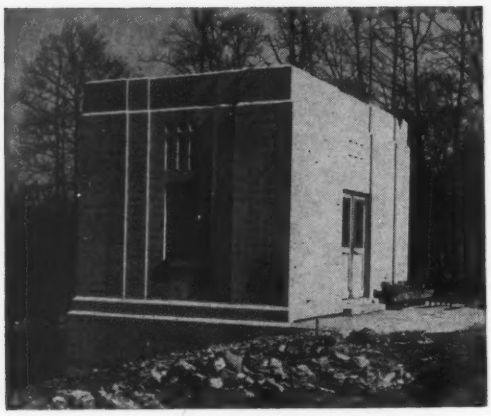


Gate house at sedimentation tank of Ashland, Ky., waterworks.

The Waterworks Digest

Abstracts of the main features of all important articles dealing with waterworks and water purification that appeared in the previous month's periodicals.

Slow Sand Filters at Yuma

At Yuma, Arizona, slow sand filters treat a water with 1300 to 23,400 ppm turbidity before sedimentation. Four settling basins with 3.4 mg total capacity reduce the turbidity to about 20 ppm in winter and 50 ppm in summer. The basins are cleaned twice a year, 9″ to 10″ of silt accumulating between cleanings. The four filters consist of 12″ of coarse gravel, 6″ of pea gravel and 18″ of sand. They have a total area of 10,275 sq. ft. and operate at about 5 mgad, reaching 12 mg under peak conditions. They are washed once a day normally, but 2 or 3 times under peak conditions, using a home-made machine similar to the Blaisdell, the sand being stirred up by a revolving rake with hollow teeth through which water jets. The cost of operation in 1942 averaged $8.55 per mg for operating labor, $1.24 for chlorine, $1.33 for copper sulfate (used for algae in the settling basins), and $10.78 for miscellaneous supplies and plant maintenance, a total of $21.90.[F34]

Water Waste Survey Benefits

To avoid the necessity of enlarging its filter plant, Allentown, Pa. had leakage survey made by the Pitometer Co., including testing of all meters 4″ or larger and the slip and efficiency of the pumps. This survey located 190 underground leaks in mains and services (all services are lead, many of them 75 to 100 yr. old) that were wasting 3,170,000 gpd; defective plumbing fixtures wasting 158,000 gpd, and 330,000 gpd under-registration of industrial meters. One unauthorized use from a fire line averaged 290,000 gpd. The water demand is now between 17 and 18 mgd compared with 19.5 mgd before the survey, although the industrial use has increased over 1 mgd meantime. The total cost of the survey was $21,083, or $15.80 per million gallons saved in one year. During the survey 200 of the 2750 street valves were found broken or leaking.[E8]

Army Camp Water Supplies

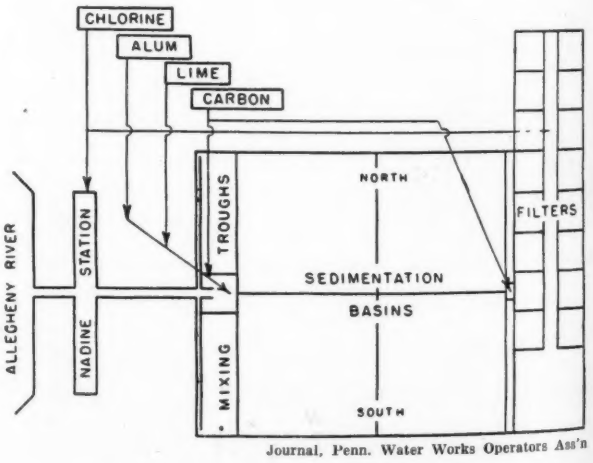
The extremely high standards employed in constructing the early cantonments of the "mobilization type" were not justified. A "theatre-of-operations" type followed, in which the buildings were the cheapest possible construction, with no water in the individual barracks, the toilet and bathing facilities being confined to large central bath houses. These lowered water consumption to about 70 gpd per capita. The latest development is the "field camp," consisting of tents without floors, latrines instead of water-borne sewage, and water furnished only for mess halls and bath houses, which are located along a single distribution main. Consumption of 50 gpd is provided for. Even in these camps at least 80% of the men bathe every day.

Permanence is not aimed at. For water mains, light steel pipe dipped and wrapped is used. Wood is used for elevated water tanks, but peak-capacity pumps are often used instead as cheaper. Surface reservoirs are substituted where possible as they cost only 1 or 2 cts. per gal., against 10 cts for steel tanks and 25 to 30 cts for wood. In air bases, covering large areas, the buildings requiring water are concentrated as much as possible to minimize length of mains.[L4]

Odor Control In Pennsylvania

In treating Allegheny river water at Nadine, Pa., alum and lime are used when pH is above 5.5, and lime and calgon with acid water with a manganese removal treatment. The carbon is fed as slurry directly on top of the filters, 20 to 50 lb. per m.g., as the influent is turned onto the filter after washing. The slurry contains 1.5 to 2.0 lb. of carbon per gal. The carbon reduces the threshold odor to from 3.0 to 2.0 at the end of the filter run. Threshold odors are usually increased by pre-chlorination. Odor tests are run once daily on raw and prechlorinated waters, settled water effluent of filters, outlet of reservoir at filter plant and a tap sample in town. There is always one of the 16 filters that is not treated with carbon and its effluent is used as a blank control. The odor of the raw water ranges from about 4 to 15; filtered water without carbon from 2 to 4, and with carbon from 2.0 to 2.5.

Shenango river water at Newcastle is treated with alum coagulation, aeration, 8 hr. sedimentation, rapid filtration, lime and chlorination. At times raw odors became intense and the addition of ammonia to settled and filtered water was begun in 1930. There was only slight decrease of the musty odors when ammonia was applied well ahead of the chlorine, but later when applied only a foot ahead there was immediate increase of 0.30 ppm in chlorine residual, the ammonia dose being 0.24 ppm



Journal, Penn. Water Works Operators Ass'n

Flow sheet of treatment at Nadine, Pa.

and the chlorine 0.94 ppm. Ammonia is now so used in filtered water all the time and in raw water when algae odors are bad. The pre-ammonia-chlorine treatment extends the residual onto the filters, maintaining them in better operating condition. Medicinal odors are removed by activated carbon applied to either raw or settled water. It can be applied close to the pre-ammonia-chlorine treatment. It stabilizes sludge in the settling units. It is effective on chemical, hydrocarbon and medicinal odors, a dose averaging 0.2 gpg being used. For musty, septic, sulfuretted and decomposition odors, ammonia-chlorine treatment is used, the dose varying from ¼ to ⅛ ratio.[U1*]

Silver as a Water Disinfectant

Use of silver for disinfecting water has advantages over disinfectants of electro-negative nature. In certain forms of application it has the least toxic index known, it is not an irritant and it does not interfere with the taste of the water. Prolonged storage of silver-sterilized water will not result in evaporation of the disinfectant; such water retains germicidal qualities for more than a month. The non-recoverable expenditure of silver in sterilization should not exceed $5 per million gallons.[A65]

Standard Specifications For Coatings for Steel Pipe

The A.W.W.A. standard specifications for coal-tar enamel protective coatings for steel water pipe—7 A .5 and 7 A .6—1940—filled a definite need; they have established orderly procedures which are practical, understandable, economical and effective. Although their basic principles are firm they can be used without restricting the judgment of the specifying engineer. In the three years since adoption they have been used in more than a thousand steel water line projects. They benefit the owner of the water line because he knows he gets a job of known quality; the designing engineer, because their excellence is not questioned; and the manufacturer and contractor, by defining clearly properties and qualities of materials and laying procedures and removing uncertainties in competitive bidding.[A72]

Chara Softens Water

Observations made at Judson reservoir, in Southern California, showed that Chara, an aquatic plant, reduces the hardness of the water in which it grows to a remarkable extent and has an inhibiting effect upon algae, due to its ability to utilize the bicarbonates of calcium and magnesium as a source of carbon in the process of photosynthesis. As Chara spread in the spring of the year, the pH rose, total alkalinity decreased, and algae died off. Wild ducks fed on it in August, and these changes were then reversed; also this prevented the tastes that would have been imparted to the water by the dying chara. The M.O. alkalinity decreased from 162 in April to 109 in July and had increased again to 129 by Sept. 30.[G20]

Chloride Content Of Massachusetts Waters

Comparisons of past and present data appear to indicate changes in the normal chloride content of unpolluted waters in Massachusetts, and a study was made to verify and explain these changes. Analyses of fog and rain water have yielded considerable concentrations of chlorides and have shown that fog that had traveled over warm sea water contained a greater amount of chlorides than that which had traveled over cold sea water. During periods of increasing rainfall the chloride content of both ground and surface waters tends to decrease. The

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general conclusions were: "1. The chloride content of waters decreases rapidly to a distance of about 50 miles from the ocean, decreasing more slowly farther inland, the limit of our observations in these notes being 125 miles. 2. There is a distinct variation in the normal chloride content of 1.5 to 0.5 ppm of chlorides due to antecedent and concurrent rainfall conditions. This variation, however, in turn decreases with the distance from the sea."[B3]

Unusual Features In Beckley's Plant

Beckley, W. Va., in the fall of 1941 put into operation a filter and pumping plant 10 miles from the city, taking water from a creek, where 400 m.g. is impounded by a concrete dam. Among the unusual features is an aerator above the mixing chamber consisting of two horizontal circular steel trays welded to a vertical 16" pipe, one about 2 ft. above the other, each tray having a diameter of 8 ft. and 7,000 3/16 inch holes in its bottom. From the mixing chamber the water passes to two sedimentation basins, which are welded steel tanks 56 ft. diameter with spiral baffles, giving 4 hr. detention at the design rate of 3 mgd. The filters occupy the top 9 ft. of four welded steel tanks 15 ft. diameter and 14.5 ft. deep, the bottom 5.5 ft. serving as clear water storage. The filters were later equipped with Palmer filter bed agitators.

Filtered water is pumped 4600 ft. to a 1 mg storage tank 165 ft. higher, and 205 ft. higher than the three distribution tanks in the city. The pressure in the distrbution system is maintained practically constant by a pressure regulating valve which is located 245 ft. below the storage tank and 40 ft. below the distribution tanks, maintaining the water level in the latter within a range of 5 ft.

The 11 miles of pipe between the plant and the city is 16" and 14" steel pipe tested to 600 lb. per sq. in., containing 1500 flexible couplings. Tested after completion for water tightness it showed absolutely no pressure loss at 100 lb. above working pressure.[G16]

The treatment consists of break-point chlorination for oxidation of iron, removal of odor and taste, and color removal; alum and lime for coagulation; lime for pH adjustment of finished water, and ammonia to prevent taste. Color is reduced from 250 ppm to a trace; CO^2 from 18 to 0; hardness is increased from 27 to 37 per pH from 5.6 to 8.3. Without ammonia, the chlorine reacted with the coal tar pipe coating in the main to give a phenol taste. At first there was trouble with mud ball formation in the filters, which no variations in washing remedied until the Palmer agitators were installed; these effected a cure in three weeks and doubled the filter runs.[G17]

War and Postwar Problems

From several papers on this subject published by A.W.W.A. we abstract several items giving suggestions and ideas not previously reported in these columns.

The use of asbestos-cement and concrete pipe has expanded so greatly that manufacturers are far behind in filling orders. Use of reinforced concrete pipe effects important savings in critical materials; its use for 20 miles of 36" pipe for 100 ft. head in one job required only 36 lb. of reinforcing steel per linear foot—about 1/3 that of the thinnest steel shell pipe that could be used.

Peak hour rates of water consumption at camps are high due to the "simultaneous" habits of the trainees. At WAAC camps the peak comes after drills in the afternoon, partly due to the women washing their stockings and underwear then. Such peak uses can frequently best be met by surface storage of a type using little critical materials, and an automatic electric booster pump. In many cases rates of filtration necessarily have been

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stepped up and more than normal amounts of coagulant and chlorine used—not to be recommended for ordinary times but justifiable during this emergency.[A59]

Use of hand labor where machines would be more economical, in the anticipated postwar superabundance of labor, should never again be practiced. Normal rules of employment, contracting, etc., should be adhered to. Work profitable for water works include substituting larger pipe for too-small mains; installing more hydrants and hydrant valves; substituting manholes for valve boxes; testing and repairing old valves, and changing spindles where necessary to make all valves open in the same direction; surveys to locate leakage and high pressure losses; installation of elevated tanks to equalize pressures and reduce pumping costs; install meters; provide more adequate housing for the maintenance department; provide a softening plant; bring interrupted maintenance work up to date; replace obsolete equipment and office methods; build up stocks of materials to prewar practices; expansion of reforestation and sanitation work on watersheds; development of additional or standby sources of supply. "The important thing is to have the surveys and the investigations made and the plans and specifications ready."[A60]

All small towns should have waterworks systems, for improvement of public comfort and convenience, and savings in fire insurance premiums. The last has a general appeal as providing a direct financial return for the expenditure. The savings in fire insurance premiums, prorated to each home, are sufficiently significant to offset materially the annual cost of financing a water works system. Figures obtained from nine Maryland towns of 1145 to 278 population show that the fire insurance rates in them were reduced from 32% to 54% by installing water works systems.[A61]

Estimating High Chlorine Residuals

It is a fallacy to assume that the cherry red color produced with orthotolidine at high residuals is a reliable indication of the amount of chlorine present. The holoquinone of othotolidine produced at low pH values is the only color suitable for the quantitative colorimetric estimation of chlorine residuals of any magnitude, using orthotolidine. Modifications of the "Standard Methods" procedures using these holoquinones, known as the "equal volume" and "drop dilution" methods are applicable for determination of high chlorine residuals, the latter being particularly valuable for use in emergency water main sterilization due to its utilization of existing standards and equipment.[A64]

Bibliography of Waterworks Literature

The articles in each magazine are numbered continuously throughout the year, beginning with our January issue.

c, Indicates construction article; *n*, note or short article; *p*, paper before a society (complete or abstract); *t*, technical article.

A *Journal, American Water Works Ass'n*
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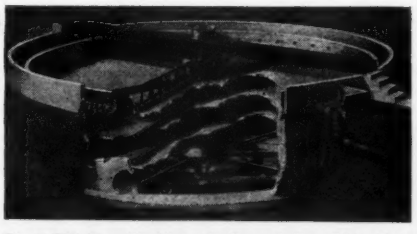
59. Wartime Problems of Supply, Operation and Design. By Louis R. Howson. Pp. 543-548.
60. Canadian Planning for Postwar Reconstruction. By W. C. Miller. Pp. 549-555.
61. Postwar Planning and Possibilities of Reduced Fire Insurance Premiums as a Factor in the Cost of Small Town Water Works Systems. By James R. McComas. Pp. 556-561.
62. Water Works Accounting Practices in Canada. By C. W. Eastwood. Pp. 562-567.
63. Surface Washing of Filters at Orrville, Ohio. By James E. Specht. Pp. 568-570.
64. Estimation of High Chlorine Residuals. By A. E. Griffin and N. S. Chamberlin. Pp. 571-578.

P.F.T. Clarifiers for Rapid Precipitation of Sewage Solids



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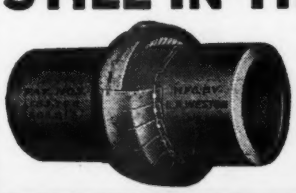

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65. Water Sanitation With Silver. By Alexander Goetz. Pp. 579-584.
66. Ozone Treatment of Water. By Victor Hann. Pp. 585-591.
67. Determination of the Phenols Content of Surface Waters. By R. D. Scott. Pp. 592-594.
68. Scalar Diagram for pH of Calcium Carbonate Equilibrium. By A. A. Hirsch. Pp. 594-596.
69. Color Removal With the Accelator. By J. M. Kahn. Pp. 597-600.
70. Michigan Water Works School on Wartime Maintenance of Water Service. Pp. 601-608.
71. The Mutual Aid Training Program in Zone 22, New York State. By E. P. Stewart and H. H. Wagenhals. Pp. 609-612.
72. Acceptance and Use of A.W.W.A. Standard Specifications for Coal-Tar Enamel Protective Coatings for Steel Water Pipe. By Deming Bronson and George B. McComb. Pp. 613-623.

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2. Suit Your Building to Its Neighborhood. By Arthur L. Shaw. Pp. 3-9.
3. Variability in the Normal Chloride Content of Surface and Ground Water Supplies in Massachusetts. By Francis H. Kingsbury and Edward W. Smith. Pp. 10-14.
4. Rainfall in New England. By George V. White. Pp. 15-62.
5. Water Supplies and Iron Removal Plant, Provincetown, Mass. By Paul F. Howard. Pp. 63-72.

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4. *p.* An Engineer's Notes on Water Purification. By S. G. Barrett. Pp. 151-154.

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5. Pollution of Water Supply Reservoirs by Birds. P. 167.

E *Engineering News-Record*
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8. Waste Water Survey "Saves" Plant Capacity. By W. R. Schnabel. Pp. 71-73.

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33. Good Results at Small Plant. By Henry A. Ehlers. Pp. 394-397.

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34. Slow Sand Filters Handle Turbid Water. By Glenn C. Boyer. Pp. 440-442.
35. New Drinking Water Standards. Pp. 443-445, 460.

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16. The New Water Supply of Beckley, W. Va. By W. D. Kelley. Pp. 153-158.
17. *p.* First Year of Operation of Beckley's New Water Supply. By E. E. Chandler. Pp. 158-160.
18. The Watersphere of Madison, Wis. By L. A. Smith. Pp. 161-164.
19. *p.* The Procurement and Assignment of Sanitary Engineers by the WMC. By C. W. Klassen. Pp. 165-166.
20. Biological Water Conditioning. By Henry C. Myers. Pp. 185-186.

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11. Soft Water in South Dakota. By Ernest R. Myron. Pp. 57, 59.

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4. Army Camp Water Supply Systems. By James Giraud. Pp. 219-221.

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12. *p.* Overcoming Plankton Difficulties at Hamilton, Ont. By D. H. Matheson. Pp. 38, 68.
13. *p.* Operating Results at the Windsor Filtration Plant. By G. Hudson Strickland. Pp. 39, 62, 64, 66.
14. *p.* Improving Filter Plant Operation by Chlorination. By A. J. Deslauriers. Pp. 40, 60, 68.
15. *p.* Operating Experiences at the Calgary Filtration Plant. By W. E. Robinson. Pp. 41-42, 54, 56, 58.

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24. Creston, Iowa, Bought Water Works, Doubled Capacity and Eliminated Shortage. By J. B. Russell. Pp. 14-15.
25. Water Softening Increases Consumption at Oak Lawn, Ill. By Herbert De Reuter. P. 26.
26. Precast Joints in Split Repair Sleeves. By Walter Turner. Pp. 36, 38.

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3. Blackout of Algae Growth With Activated Carbon. By John P. Harris. Pp. 1-7.

W *Johnson National Drillers Journal*
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3. Ground Water: Extended or Gravel Cone Treatment. Pp. 1-5.
4. *c.* Drilling 1,160 ft. Water Well for Asbury Park, N. J. Pp. 10-13.

X *Journal, North Carolina Section, A.W.W.A.*
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6. Proposed Program for Protection of Water From Poison. By J. W. Kellogg. Pp. 28-31.
7. Maintenance of Public Water Supplies for Civilian Defense. By D. W. Evans. Pp. 32-45.
8. Value of Pitometer Distribution Studies to Meet Present Emergencies and Post-War Conditions. By E. Shaw Cole. Pp. 48-54.
9. Water Main Cleaning in the War Effort. By Clinton Inglee. Pp. 75-81.
10. Well Field Operating Experiences at Elizabeth City. By Robert W. Luther. Pp. 107-126.

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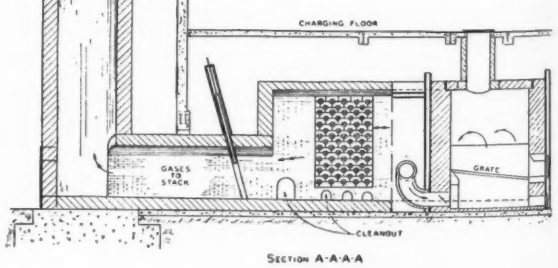

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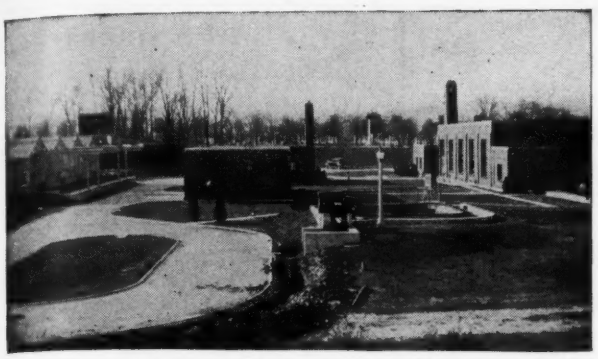

General view of Findlay, Ohio, plant. Main building at right; sludge beds and digester at left.

The Sewerage Digest

Abstracts of the main features of all important articles dealing with sewerage and sewage treatment that appeared in the previous month's periodicals.

Stage Aeration Of Activated Sludge

In studying the effect of "stage addition" of return activated sludge to aeration tanks at Two Rivers, Wis., one half the normal amount was applied at Sta. 1 (the head of the tank) in order to maintain about 800 ppm of aeration solids there, and one fourth at each of two other stations, from 9 A.M. to 9 P.M. At night none was added at Sta. 1, but in spite of this, the suspended solids were as high in the morning as during the day. Even when sludge was added only at the far end of the tank, conditions were practically the same. The only answer appeared to be that there was back flow in the tank. Efforts to eliminate this back flow were unsuccessful, and "the feasibility of stage addition to improve economy and capacity of activated sludge plants is unanswered"; and the benefits of this, of incremental feeding of sewage or tapered aeration can be evaluated only if back flow can be eliminated or its conditions evaluated.[H24]

Sludge for Victory Gardens

The State Dept. of Health of Connecticut, in a bulletin discussing use of sewage sludge for fertilizing lawns, flower gardens and food crops, advises that the use of raw sludge in any form is not recommended. Digested sludge has about the same total nitrogen and total phosphoric acid content as sheep manure, but practically no potash. But about 50% of it (dry weight) is humus and a good soil conditioner. It acidifies the soil, and lime should be used with it at intervals. It may be used as a top dressing for trees or lawns, turned under for vine or other crops. Digestion, with air drying or vacuum filtration affords sufficient protection against intestinal diseases. For flower gardens it provides humus for the hot summer months and a long-yielding supply of nitrogen. It is excellent for trees and shrubs.[G10]

Army Lavatory Conserves Critical Materials

In a plan for a communal lavatory developed by the Construction Div. of the Corps of Engineers for theater-of-operations cantonments all plumbing and sanitary fixtures are eliminated and replaced by a concrete latrine pit with a wooden top and double row of seats, a wash trough of half tile, and a half-tile flushing trough for a urinal. All waste water from the wash troughs and shower baths is used for flushing the latrine pit into a sewer. The urinal is flushed by means of a 40-gal. tank with a 3″ dosing siphon, the flushing water discharging into the latrine pit. This saves the water used in toilet fixtures, which amounts to a minimum of 10 gpd per man.[E11]

Sanitary Fill At San Francisco

For 10 years San Francisco, Calif., has disposed of its mixed refuse by sanitary fill. Considerable garbage goes to hog farms, and the larger part of the refuse used is dry rubbish. This is carried to the fill location in gondolas, and is so dry that these are not washed after unloading but are swept out with a stable broom. The refuse is covered at least 12″ deep with earth from a nearby hill.

The soft mud under the toe of the fill is 40 ft. deep, and the fill pushes this out. The final elevation of the fill is 8 ft. above the mud line, and the fill is made about 60 ft. deep to allow for the expected 20% ultimate settlement in 8 or 10 yrs. The temperature in fresh fill rises to about 160° and steam rises from it, and a black liquor with relatively little odor trickles from the toe.[b6]

Pumping Grit With Compressed Air

At Olean, N. Y., grit is removed from the grit chamber of the treatment plant by means of an air-lift pump. By using a 105 cfm air compressor already owned (a 200 cfm would be better) and scrap materials the device was constructed at a cost of $75, while conveyor equipment would have cost $5,000. Removal by hand had required 6 man-hours of labor per week; the air pump does it in 30 min., including first cleaning the grit by air agitation. It removes grit and larger objects such as towels with ease.[E9]

Bibliography of Sewerage Literature

The articles in each magazine are numbered continuously throughout the year, beginning with our January issue.

c. Indicates construction article; *n*, note or short article; *p*, paper before a society (complete or abstract); *t*, technical article.

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13. Grit Chamber Design. C. B. Townsend and C. J. Hartley. Pp. 137-138.

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14. *p.* A Cubic Yard of Percolating Bed Material and Assumptions Based on Experimental Evidence. By H. H. Goldthorpe. Pp. 177-179.
15. *p.* Experiences With Mechanical Equipment at Epsom and Ewell Sewage Works. By H. H. Stanbridge. Pp. 163-165.

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16. Contact Aeration for Sewage Treatment. By John Hurley. Pp. 183-185.

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8. Sanitary Fill Experience at San Francisco. Pp. 74-77.
9. *n.* Air Lift Pump Used to Clean Sewage Disposal Grit Chambers. P. 77.

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11. Army Lavatory Conserves Critical Materials and Water. Pp. 116-117.

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10. Sludge as Fertilizer in the War Emergency. By LeRoy W. Van Kleeck. Pp. 177-178.
11. Wartime Substitute Manhole Covers and Frames. By George E. Symons. Pp. 179-181.
12. Sampling Errors. By Harold A. Thomas, Jr. Pp. 182-184.

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26. Post War Sanitation Planning Urged at National Conference. Pp. 239-242.

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7. Winchester, Va., Plans a Postwar Sewage Treatment Plant. Pp. 39-40.

P *Public Works*

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20. Up-to-the-Minute Cranston, R. I., Sewage Disposal Plant and Sewerage System. By Ralph W. Horne. Pp. 20-23, 40, 42.
21. Suspending 1700 Feet of Sewer From a Bridge. P. 39.
22. *p.* High Nitrate Content in Biologically Purified Sewage. P. 47.
23. *n.* Glue Works Waste Recovery System. P. 55.

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When you need special information—consult the classified READER'S SERVICE DEPT., *pages 73-75*

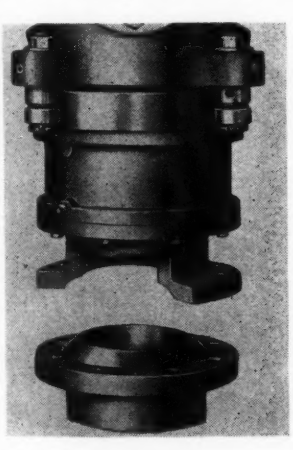
Keeping Up With New Equipment

Yeomans Leveler for Rotary Distributors

Yeomans Brothers Company
1409 Dayton St., Chicago

The Leveler consists of a bronze ring with convex spherical upper surface, set in a shallow recess in the top flange of the distributor base fitting. A corresponding concave spherical surface in the bottom flange of the base of the inner distributor column or of a flanged pipe extension between the distributor column and the base fitting, forms a water-tight adjustable joint with the ring, by means of which the entire distributor mechanism can be tilted several degrees in any desired direction. As the leveling ring serves to center the two flanges where they are parallel, extra large clearance holes and, when necessary, self-aligning washers are provided to secure adequate seating of bolt heads and nuts when releveling is completed. Forcing or set screws are provided in the flanges for ease in releveling and for locking the flanges after the bolts have been set up.

Where the Yeomans Leveler is to be applied to an existing distributor it is built as a complete sub-assembly with special flanges to be inserted between the base fitting and column flange already



Leomans Leveler.

in place. This requires raising the distributor assembly but does not involve disturbing the base fitting or breaking and repouring the inlet pipe joint. Reduction in operating head due to raising the distributor is not more than 6 or 8 inches.

It is not uncommon for a trickling filter structure with rotary distributor, after several years of service, to settle out of level due to bad sub-soil or other conditions. Aside from ill effect on drainage efficiency due to inclination of the bed, the excessive stresses set up by unbalanced operation will soon cause serious damage to the thrust and guide bearings in the distributor—and destroy them unless the condition is corrected.

In a distributor of the type in most general use, with an outer column carrying the arms rotating about an inner column on which it is mounted by thrust and guide bearings, it is essential that the two columns be in concentric relation to each other. In the event of axial misalignment which is certain to damage the mechanism, it becomes necessary to dismantle the machine, break the inlet pipe joint at the bottom, relevel and regrout the base fitting and reassemble the distributor—a time-consuming and costly operation which may have to be repeated at intervals.

The Yeomans Leveler makes it possible to restore the vertical position of the distributor as a unit, without any dismantling or breaking of joints, and by using ordinary wrenches.

New Protective Coating for Extremely Corrosive Conditions

United Chromium, Inc.
51 East 42nd St., New York, N. Y.

Twelve-page data bulletin summarizes the unusual properties of Ucilon, a new surface coating material that stands up under many of industries' most corrosive service conditions. Because Ucilon is formulated with new and improved synthetic resins, it produces tough, flexible coatings that are resistant to organic and inorganic acids, alkalies, salts, alcohol, gasoline, oils, greases and moisture; it also has excellent dielectric strength and can be readily applied to wool, metal, concrete and other surfaces by brushing, spraying or dipping.

Although the special war applications of Ucilon cannot be revealed, this booklet illustrates many essential uses and will suggest countless more where corrosion is a costly and time consuming problem —or where Ucilon can be used in place of more critical materials. Copies available on request.

Vertical Turbine Pump Bowls

Layne & Bowler, Inc.
Memphis, Tenn.

These bowls are intended primarily for pumping water from flowing streams or lakes for war plants, but may be used in large diameter wells for industrial or municipal water supplies.

The Memphis factory recently has fabricated five complete pumping units for a synthetic rubber plant. These units are equipped with the new two-stage 30" Type SKHC Bowls, designed to deliver 11,000 gallons per minute against a total dynamic head of 169 feet and are driven by 500 horsepower, vertical, hollow shaft motors. They will be installed in a large diameter caisson and pump water from a flowing stream.

Layne & Bowler Pump Bowls.

Another lot of fifteen complete pumps, also for a synthetic rubber plant, will have newly developed 36" Type RKMC, single-stage bowls. The capacity range will be from 11,000 to 14,600 gallons per minute, and the pumps will be driven by 500 horsepower, vertical, hollow shaft, synchronous motors.

This new line of high-capacity, large diameter bowls includes designs for capacities up to 16,000 gallons per minute, and all bowls are true turbine type. Noteworthy features are the unusually high efficiencies throughout a wide capacity range and the non-overloading type impellers used. These features make the new bowls especially desirable for pumping from rivers or streams where fluctuating water levels are encountered, with consequent variation in capacities and pumping heads.

Operation and Maintenance of Heavy Duty Midget Chlor-O-Feeder

%Proportioneers, Inc.%
9 Codding St., Providence, R. I.

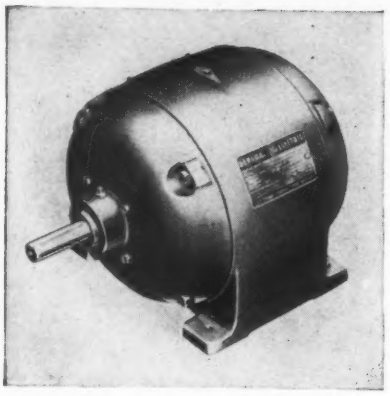
These new bulletins — HDM and HDM-COF—give complete information on the installation, operation and maintenance of the Heavy Duty Midget Chlor-O-Feeder. Bulletin HDM gives complete specifications. These bulletins are available to the thousands of users of Chlor-O-Feeders now in service and for those who contemplate the purchase of the heavy duty midget Chlor-O-Feeder. Write for copies.

New Line of Totally Enclosed Tri-Clad Motors

General Electric Company
Schenectady, New York

A new line of totally enclosed motors, the most recent addition to the widely known group of Tri-Clad motors, has been announced by the Motor Division of the General Electric Company. Available in both the polyphase, 60-cycle, induction type and the single-phase, 60-cycle, capacitor type, the new motors are especially designed for use under conditions where abrasives, chemicals, rain, snow, and excessive dirt are encountered.

The polyphase motors are furnished



General Electric Tri-Clad Motor.

in frame sizes 203 to 225. They include ½, ¾, and 1 hp at 900 rpm; ¾, 1, and 1½ hp at 1200 rpm; 1, 1½, and 2 hp at 1800 rpm; and 1½ and 2 hp at 3600 rpm. The single-phase motors are furnished in frame sizes 203 and 204, and include ¾ hp at 1200 rpm; 1 and 1½ hp at 1800 rpm; and 1½ and 2 hp at 3600 rpm. The mounting dimensions of these motors are interchangeable with Tri-Clad open motors of the same rating.

These new motors have all the important basic features of the Tri-Clad group. This includes triple protection—protection against physical damage, electrical breakdown, and against normal operating wear and tear.

In addition, all parts of the motor enclosures—frame, and shields, and conduit boxes—are cast iron, thus offering exceptional resistance to rust, corrosion, accidental blows, and rough use.

Spee-Dee Printer for Blue Prints and Black and White Prints

Peck & Harvey

4325 Addison Street, Chicago, Ill.

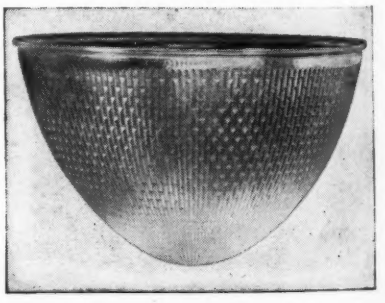
It is claimed to be a sturdy, convenient, portable, table model which can be plugged into any standard electric outlet and is easy to operate. It comes in two sizes: for prints up to 12 x 18 and 18 x 24. The illustration shows the 12 x 18 *Spee-Dee* Printer with two 8½ x 11

Spee-Dee Printer.

prints inserted. The actual printing surface is oversize on both size machines. This prevents the crowding of prints, overlapping or blurred edges. Printing on a curved glass surface gives perfect contact without the inconvenience of wrapping the prints around a cylinder.

With the *Spee-Dee,* you can make either blue prints or black and white prints in half-a-minute. Exposure time is frequently as little as twenty seconds. Developing time for a black and white print (Directo process) is only 10 seconds.

You can duplicate tracings, drawings, letters, invoices, or any written or printed matter on the *Spee-Dee,* quickly and clearly.



New Westinghouse Smooth Surface Globe.

New Street Lighting Globe Reduces Maintenance

Westinghouse Electric and Mfg. Co.
East Pittsburgh, Pa.

For street and highway lighting, a new smooth surface globe which reduces maintenance is announced.

Perfectly smooth on the outside, the new globe is finished on the inside with a uniform pattern of rectilinear configurations, through which light rays are diffused horizontally. The smooth outside surface retards the collection of nor-

STURDY TROOPERS
There is nothing to match hard-boiled war service to disclose the weaknesses or prove the strength of a piece of machinery.
That the Buffalo-Springfield roller is meeting every test . . . proving itself a good trooper testifies to its inherent soundness of design and rugged construction.
For the duration, in service on five continents and available to military contractors only.
THE BUFFALO-SPRINGFIELD ROLLER CO.
SPRINGFIELD, OHIO
BUFFALO-SPRINGFIELD ROLLERS

When you need special information—consult the classified **READER'S SERVICE DEPT.,** *pages 73-75*

mal dust and dirt, because there are no grooves to accumulate smoke and grease film. Scrub-brush cleaning is no longer necessary, and time required for cleaning and drying has been cut in half.

The new globe is of pressed construction, resulting in a more uniform pattern and more uniform light distribution. The pressing process produces a smooth, rounded, "chip-proof" fitter edge which gives added strength and structural support to the globe. It is available in two types, long and short.

Additional information may be secured from the Westinghouse Lighting Division, Edgewater Park, Cleveland, Ohio.

INTERESTING TRADE NEWS

Major A. E. Higgins.

Higgins Enters Air Corps

A. E. Higgins, Vice President and Sales Manager for the Pittsburgh Equitable Meter Company—Merco Nordstrom Valve Company, Pittsburgh, Pa., has been commissioned as Major in the U. S. Air Corps, and called immediately for active duty. A veteran of World War I, Major Higgins has held a Reserve Officer's Commission for many years.

Major Higgins originally qualified as an Army Air Pilot in 1918. He has since flown his own plane throughout his business career, and enters the Air Corps with over 6000 hours solo credit.

Steacy-Schmidt Mfg. Co.

The name STEACY-SCHMIDT MANUFACTURING COMPANY has been changed to Hardinge Manufacturing Company. This involves no change in management or company policies.

Hardinge Manufacturing Company (formerly Steacy-Schmidt Manufacturing Company) is a Pennsylvania corporation and is a subsidiary of Hardinge Company, Incorporated, a New York corporation.

The principal reason for the change is to identify the two companies more closely with each other than was possible heretofore.

As in the past, Hardinge Company, Incorporated, the parent corporation, sells specialized equipment to mining, chemical, and other process industries, while Hardinge Manufacturing Company, in addition to manufacturing for the account of Hardinge Company, Incorporated, also manufactures in its pattern, foundry, plate, machine, and assembly shops to the specifications and designs of other corporations and government agencies.

Mack Trucks Move

The executive offices of Mack Trucks, Inc. are now located in the Empire State Building. The new home offices are on the 20th floor, comprising 22,900 square feet of floor space.

Gar Wood Promotes Berg

A. C. Berg has been appointed manager of the Road Machinery Division of Gar Wood Industries, Inc., Detroit, according to G. A. Bassett, President.

Mr. Berg, who joined the company in 1919, became Assistant Manager of the Road Machinery Division when the division became a part of Gar Wood Industries, Inc., in 1934. R. S. Headly has been appointed Assistant Manager to Mr. Berg.

Asphalt Institute Establishes Dallas, Texas, Office; Appoints Hugh A. Wallace, District Engineer

Bernard E. Gray, General Manager of The Asphalt Institute, has announced the appointment of Hugh A. Wallace as District Engineer for the territory comprising Texas, Oklahoma, and Arkan-

HOW'S YOUR STOCK OF MATHEWS BARRELS?
It Pays To Keep Enough On Hand!
Mathews Hydrants take the dig out of repair work . . . eliminate long out-of-service periods . . . and bring the reconditioning job into the shop, where it belongs.
The entire barrel, including all working parts, easily unscrews from the elbow connection under the ground. Then you just lift it out through a loose protection case and replace it with a new or reconditioned Mathews Barrel. The whole job takes only a matter of minutes. Back to the shop goes the barrel you took out, where it is reconditioned at your leisure for the next replacement. (Of course, minor repairs can also be made right on the job.)
If you are using Mathews Hydrants, now is the time to check your stock for replacement barrels. If you are considering new installations, send for special booklet explaining the many worthwhile advantages of Mathews Hydrants.
MATHEWS HYDRANTS
400 CHESTNUT STREET, PHILADELPHIA, PA.
ESTABLISHED IN 1803
Made by R.D.WOOD Company
MANUFACTURERS OF SAND SPUN PIPE (CENTRIFUGALLY CAST IN SAND MOLDS) AND R. D. WOOD GATE VALVES

sas, with office in the Southwestern Life Building, Dallas, Texas.

Mr. Wallace's engineering experience for the past twenty years includes service in the Texas State Highway Department and the Southwestern Division of the U. S. Engineers. For the past ten years in the Maintenance Division at Austin, his work included general supervision of Force Account Construction for the entire state of Texas.

Mr. Wallace is now available to extend the engineering, research, and promotional facilities of The Asphalt Institute to Highway Engineers and Contractors.

Griffin Wellpoint Corp.

The Griffin Wellpoint Corporation, New York, N. Y. has established a Southern branch office and warehouse at 633 North Myrtle Avenue (on S. A. L. Siding), Jacksonville, Florida, William J. Carr, Manager.

A large stock of Wellpoint Systems, Jetting Pumps, Portable Gasoline Driven Generators, etc., will be carried in stock for prompt shipment.

Fred W. Deutsch Made Vice President of Everson Manufacturing Co.

At the recent annual meeting of the Everson Manufacturing Company, Fred W. Deutsch was re-elected to the Board of Directors, and made Vice-President. Mr. Deutsch has been connected with the Everson Manufacturing Company since the beginning of 1939 and prior to that was employed for approximately 12 years by the Permutit Company of New York City. His entire business career since leaving Stevens Institute of Technology has been connected in one way or another with the Water Treatment Field.

Climax Engineering Interests Buy McAlear Manufacturing Company

Ownership of McAlear Manufacturing Company, Chicago producer of valves, regulating and control equipment, was acquired by the interests controlling Climax Engineering Company, leading manufacturer of internal combustion engines, power units and generating sets.

Edward F. Deacon, Climax president, will be president and general manager of the McAlear Company, it was stated by Mr. Deacon and Owen L. Coon, chairman of the board of General Finance Corporation, of which both companies are now subsidiaries. Mrs. P. G. McAlear, formerly president and now chairman of the board of the McAlear Company, will continue to be actively identified with the management.

"The important immediate result of this acquisition," Mr. Deacon indicated, "will be the supplementing of engineering talents of each company. This, plus economies of production and distribution, should accrue to the direct benefit of customers of both companies in the post war period."

On May 7th, the Army-Navy "E" award was conferred on Climax Engineering Company and its employes for high achievement in the production of war materials.

Have You "Slacker" Sewers?

These are no days for reduced capacities, whether they be in men, machines, or sewers. If your sewerage system is making a half-hearted showing under war time overloads the answer may not be larger sewers or better sewers but better-performing sewers.

RESTORE WITH STEWART EQUIPMENT

Get the most out of what you have by cleaning with STEWART equipment. Restore them to full capacity and keep them that way. Whatever the job to be done, STEWART rods, tools, and other equipment can help you to do that—easily, speedily, and economically.

SEWER AND CONDUIT RODS

Just one item of the large STEWART line.
There's STEWART equipment for every need.

AVOID WASTE

Working without proper equipment is too wasteful for war time conditions. As the first step to speed-up, get the new complete STEWART catalog. Check your needs by it, then consult us about our various plans for increasing your sewer capacities. This is *saving* money, not spending it. Address, without obligation:

W. H. STEWART
P. O. BOX 767 SYRACUSE, N. Y.
"Since 1901"

SERVICE RECORD

How long should Outdoor Water Service Devices continue in service?
Murdock installations of 20, 30 and more years ago, are operating today requiring only an occasional re-washering.
You bet "It pays to buy Murdock."

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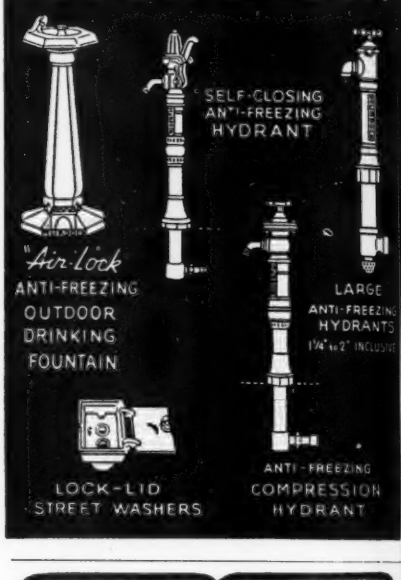

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For forty-five years we have specialized in making better settings for water meters.

But now, although we are still serving our customers to the best of our ability, we are specializing in making munitions and are as proud of our products as ever.

In spite of doing well over 50% war work we are at your service in helping maintain your Ford equipment at maximum efficiency.

FORD METER BOX CO.
WABASH, IND.

Readers' Service Department

These booklets are FREE but distribution is restricted to those actively engaged in engineering or construction. Use the coupon below or write the manufacturer direct, mentioning PUBLIC WORKS.

Construction Materials and Equipment

Air Raid Shelters

3. New 8 page booklet pictures and describes a corrugated pipe shelter with gas tight end walls, emergency escape tunnel and other desirable features. Armco Drainage Products Assn., Middletown, Ohio.

Bridges

7. Teco Connectors, a new method of structural engineering, to spread the load on a timber joint more equally over the cross-section of the wood is described in new literature available from Timber Engineering Co., Dept. BS-2, 1319—18th St., N. W., Washington, D. C.

Cement Dispersion

9. "Economics of Cement Dispersion and Pozzolith" tells the complete story of how cement dispersion reduces water required up to 20% and increases workability 150%. Write The Master Builders Co., Cleveland, Ohio, for a copy.

10. A valuable treatise on available means of securing high strength, prevention of sealing, increased durability and improved wear resistance in concrete pavement construction. Master Builders Co., 7016 Euclid Ave., Cleveland, Ohio.

Cold Mix Plants

15. New catalogs and prices of Portable Bituminous Mixers in 6 to 14 ft. sizes for resurfacing and maintenance. Issued by The Jaeger Machine Co., 400 Dublin Ave., Columbus, Ohio.

Cold or Wet Weather Construction

18. Cleaver Aggregate Heaters and Dryers, Hot Water Boosters, and Automatic Steam plants are designed to speed up cold or wet weather construction. Write for illustrated bulletins. Cleaver-Brooks Co., 3112 W. Center St., Milwaukee, Wis.

Concrete Accelerators

31. New 48-page booklet in five sections explains clearly the effects, advantages and methods of using Calcium Chloride and Portland Cement mixes. Complete and packed with practical information; well illustrated; pocket size. Sent free on request by Solvay Sales Corp., 40 Rector St., New York, N. Y.

Concrete Curing

33. 64-page manual of concrete curing with calcium chlorides. Complete, handy. Contains useful tables, well illustrated. Write the Columbia Chemical Division, Pittsburgh Plate Glass Co., Grant Bldg., Pittsburgh, Pa.

Concrete

36. "Cutting Concrete Costs"—Booklet analyzes costs and outlines methods of figuring the lowest cost schedule. Notes on job planning. For copy, write Lone Star Cement Corp., 342 Madison Ave., New York, N. Y.

Concrete, Early Strength

38. 64-page manual tells how to speed up year 'round concreting, shows how to secure high early strength and greater workability at temperatures either below or above freezing. Contains many actual examples of practical concreting operations; well illustrated with more than 60 photos, charts, graphs and tables. Calcium Chloride Assn., Penobscot Building, Detroit, Mich.

Concrete Mixers

44. Catalog and prices of Concrete Mixers, both Tilting and Non-Tilt types, from 3½S to 56S sizes. The Jaeger Machine Company, 400 Dublin Ave., Columbus, Ohio.

Drainage Products

70. Standard corrugated pipe, perforated pipe and MULTI PLATE pipe and arches — for culverts, sewers, subdrains, cattlepasses and other uses are described in a 48-page catalog entitled "ARMCO Drainage Products," issued by the Armco Drainage Products Association, Middletown, Ohio, and its associated member companies. Ask for Catalog No. 12.

Drainage

71. Walker Poroswall Rapid Drain Pipe for Drainage or Water Collection is claimed to be the fastest drainage medium known. Send for latest literature explaining its many uses. Walker Cement Products Co., Little Ferry, N. J.

Graders, Patrol

105. The Austin-Western 99M Power Grader with its powerful all wheel drive simplifies all construction and maintenance; handles difficult jobs with economy and efficiency; and does better work on grading, ditching, scarifying, snow plowing, loading, mixing, bulldozing, shoulder trenching and backsloping. Write for Bulletin 1946. Austin-Western Road Machinery Co., Aurora, Ill.

Mixing Plants, Asphalt

106. The Cleaver Asphalt Mixing Plant for an inexpensive plant mix and the Cleaver Tank Car Heater and Bituminous Booster are covered in illustrated catalogs sent on request by Cleaver-Brooks Co., 3112 W. Center St., Milwaukee, Wis.

Mud-Jack Method

107. How the Mud Jack Method for raising concrete curb, gutter, walls and street solves problems of that kind quickly and economically without the usual cost of time-consuming reconstruction activities — a new bulletin by Koehring Company, 3026 West Concordia Ave., Milwaukee, Wis.

Oil, Motor

109. "Here's Proof of Ring-Free Superiority," 32 pages, illustrated, outlines the principles of lubrication and explains how by simple tests you can measure the advantages of Macmillan Ring-Free Motor Oil. Write Macmillan Petroleum Corp., 530 West 6th St., Los Angeles, Calif.

Paving Materials, Bituminous

111. New "Tarvia Manual" is packed with useful data on how to build and maintain roads with Tarvia. Each step is illustrated with excellent action pictures, 64 pp. 103 ills. Write to The Barrett Div., 40 Rector St., New York, N. Y.

Pumps

120. Interesting new booklet tells how to lengthen the life of your pumps. Explains how a little care will save a lot of wear. Write today for your copy. Homelite Corp., 2403 Riverdale Ave., Portchester,

121. New illustrated catalog and prices of Jaeger Sure Prime Pumps, 2" to 10" sizes, 7000 to 220,000 G.P.H. capacities, also Jetting, Caisson, Road Pumps, recently issued by The Jaeger Machine Company, 400 Dublin Ave., Columbus, Ohio.

123. New brochure by Gorman-Rupp Co., Mansfield, Ohio, illustrates and describes many of the pumps in their complete line. Covers heavy duty and standard duty self-priming centrifugals, jetting pumps, well point pumps, triplex road pumps and the lightweight pumps.

124. 16-page illustrated bulletin, SP-37, describes and illustrates complete C. H. & E. line of self-priming centrifugal pumps from ½" to 8", including lightweight models for easy portability. C. H. & E. Mfg. Co., 3841 No. Palmer St., Milwaukee, Wis.

Road Building and Maintenance

128. Motor Patrol Graders for road maintenance, road widening and road building, a complete line offering choice of weight, power, final drive and special equipment to exactly fit the job. Action pictures and full details are in catalogs Nos. 253, 254 & 255, issued by Gallon Iron Works & Mfg. Co., Gallon, Ohio.

Rock Drill Maintenance

130. New booklet presents through amusing cartoons useful hints on proper rock drill maintenance methods—what your men can do to get more work out of your tools with a minimum of expense for repairs and compressed air. Write The Cleveland Rock Drill Co., 3734 East 78th St., Cleveland, Ohio.

Rollers

133. New Tu-Ton roller of simple construction for use in rolling sidewalks along highways, playgrounds and other types of light rolling is fully described in a bulletin issued by C. H. & E. Mfg. Co., 3841 No. Palmer St., Milwaukee, Wis.

138. "The Buffalo-Springfield line of road rollers (tandem, 3-wheel, and 3-axle) are described in the latest catalog issued by the Buffalo-Springfield Roller Co., Springfield, Ohio."

139. "Ironeroller" 3 Axle Roller for extra smooth surfaces on all bituminous work. Booklet contains roller data and operation details. Hercules Co., Marion, Ohio.

140. This well-illustrated 16-page catalog describes the tandem, autocrat, cadet, and roll-a-plane rollers, and explains what each is intended to accomplish. Write Austin-Western Road Mach. Co., Aurora, Ill.

Rotproofing

145. Cuprinol, a rotproofing chemical that protects wood from fungi and insects, yet has no offensive odor, is non-poisonous, does not corrode metal and can be painted over. Get full details in booklet from Cuprinol, Inc., 7 Water St., Boston, Mass.

Soil Stabilization

150. "High-Service, Low Cost Roads" is one of the newer booklets using an effective combination of picture and text to set

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forth the principles and advantages of road surface stabilization with calcium chloride. Complete, interesting and well illustrated. 34 pages. Sent by Solvay Sales Corp., 40 Rector St.. New York. N. Y.

152. The Columbia Chemical Division will be glad to furnish to anyone interested complete information dealing with Calcium Chloride Stabilized Roads. This literature contains many charts, tables and useful information and can be obtained by writing Columbia Chemical Div., Pittsburgh Plate Glass Co., Grant Bldg., Pittsburgh, Pa.

154. "Soil Stabilization with Tarvia"—An illustrated booklet describing The steps in the stabilization of roadway soil with Tarvia will be mailed on request by The Barrett Div., 40 Rector St., New York, N. Y.

Spreader

187. Jaeger Paving equipment, including Mix-In-Place Roadbuilders, Bituminous Pavers, Concrete Bituminous Finishers, Adjustable Spreaders, Forms, etc.—4 complete catalogs of latest equipment in one cover, issued by The Jaeger Machine Company, 400 Dublin Ave., Columbus, Ohio.

Surface Consolidation and Maintenance

188. Detailed and illustrated presentation of the method and procedure in consolidated operations; explains how sub-soils can be conditioned to resist softening and frost action; how surfacing can be consolidated to provide smooth all-weather riding surfaces; how they can be maintained so as to prevent disintegration and gravel loss. Write the Calcium Chloride Association, Penobscot Bldg., Detroit, Mich., for Bulletin No. 29.

Timber Structures

189. "Typical Designs of Timber Structures" contains plans for 45 representative structures that have been engineered with Teco Connectors. For free copy write Timber Engineering Co., Inc., Room 6GG, 1319—18th St., N. W., Washington, D. C.

Wellpoints

195. New complete catalog, "Griffin Pointed Wellpoint Facts," just issued. Covers pre-drainage, describing wellpoints, jetting pumps, with tables, diagrams, and illustrations. Griffin Wellpoint Corp., 881 E. 141st St., New York.

Street and Paving Maintenance

290. "Blacktop Road Maintenance and Construction Equipment"—Asphalt and tar kettles, flue type kettles, spray attachments with completely submerged pumps, tool heaters, surface heaters, road brooms, portable trail-o-rollers, etc. These are all described in detail and illustrated. This modern and up-to-date equipment for blacktop airport and road construction and maintenance is based upon experience and engineering research over a period of 42 years. Write for Catalog R. Littleford Bros., Inc., 452 East Pearl St., Cincinnati, O.

Fire Apparatus

300. Detailed information and advice about specially engineered Ward LaFrance apparatus will be sent on request. Ward LaFrance Div., Elmira, N. Y.

Snow Fighting

Snow Plows

350. "Frink One-Way Sno-Plows" is a four page catalog illustrating and describing 5 models of One-Way Blade Type Sno-Plows for motor trucks from 1½ up to 8 tons capacity. Interchangeable with V Sno-Plow. Features, specifications and method of attaching. Carl H. Frink, Mfr., Clayton, 1000 Islands, N. Y.

Ice Control

351. "Make Icy Highways Safe for Traffic"—a new bulletin by Michigan Alkali Div., Wyandotte Chemicals Corp., Wyandotte, Mich., tells how to use calcium chloride for modern ice control.

Sanitary Engineering

Aero-Filter

356. "Results Produced by Aero-Filters" is a new pamphlet covering results at Temple, Texas; Paris, Ill.; Webster City, Iowa; and Mason, Mich. Write Lakeside Engineering Corp., 222 West Adams St., Chicago, Ill.

Air Release Valves

357. Automatic Air Release Valves for water, sewage and industrial uses are described and illustrated in new catalog issued by Simplex Valve & Meter Co., 6750 Upland St., Philadelphia, Pa.

Analysis of Water

360. "Methods of Analyzing Water for Municipal and Industrial Use" is an excellent 94 page booklet with many useful tables and formulas. Sent on request by Solvay Sales Corp., 40 Rector St., New York, N. Y.

Activation and Aeration

376. A valuable booklet on porous diffuser plates and tubes for sewage treatment plants. Covers permeability, porosity, pore size and pressure loss data, with curves. Also information on installations, with sketches and pictures, specifications, methods of cleaning and studies in permeability. 20 pp. illustrated. Sent on request to Norton Company, Worcester, Mass.

Blowers

378. All interested in low cost air for sewage disposal will want a copy of this catalog describing operating principles and specifications of Roots-Connersville Aerating Blowers. Write to Roots-Connersville Blower Corp., 301 Valley Ave., Connersville, Ind.

Chlorinators, Portable

379. Complete data on new portable chlorinator designed to meet emergency calls quickly and efficiently. Write Wallace & Tiernan Co., Inc., Newark, N. J.

380. "Emergency Sterilization Equipment," a new bulletin describing the advantages of Dual Drive Chlor-O-Feeders which can serve as either a permanent chemical feeder or as a portable emergency chlorinator. Order from Proportioneers, Inc., 96 Codding St., Providence, R. I.

Cleaning Sewers With Own Forces

381. A 20-page booklet describes and illustrates a full line of sewer cleaning equipment—Rods, Root Cutters, Buckets, Nozzles and Flushers. Write W. H. Stewart (Pioneer Mfr. since 1901), Jacksonville, Fla., or P. O. Box 767, Syracuse, N. Y.

Cleaning Mains

382. "Let's Look Into the Matter of Water Main Cleaning" is an illustrated booklet outlining the advantages of water main cleaning and explains how it can be done quickly and inexpensively by The National Method. Write National Water Main Cleaning Co., 30 Church St., New York, N. Y.

383. 32-page illustrated booklet explains how a city can clean its sewers and culverts with its own forces using the up-to-date Flexible Sewer Rod equipment. Illustrates and describes all necessary equipment. Issued by Flexible Sewer Rod Equipment Co., 9059 Venice Boul., Los Angeles, Calif.

Consulting Engineers

384. "Who, What, Why" outlines briefly the functions of the consulting chemist and chemical engineer. Covers various methods of cooperation, on different types of problems, with industry, with attorneys and with individuals. Foster D. Snell, Inc., 305 Washington St., Brooklyn, N. Y., will send a copy on request.

Feeders, Chlorine, Amonia and Chemical

385. For chlorinating water supplies, sewage plants, swimming pools and feeding practically any chemical used in sanitation treatment of water and sewage. Flow of water controls dosage of chemical; reagent feed is immediately adjustable. Starts and stops automatically. Literature from % Proportioneers, Inc. % 96 Codding St., Providence, R. I.

386. New circular describes and illustrates the Var-I-Feeder, a new portable chemical feeder for water main sterilization, military use or other chemical treatment. Write Chem-Feeds, Inc., 77 Reservoir Ave., Providence, R. I.

387. Everson Sterelators for all kinds of chemical feeding in stationary and portable models are described in new bulletins issued by Everson Manufacturing Co., 214 West Huron St., Chicago, Ill.

Filters

388. How to increase the capacity of filters through use of Anthrafilt and complete data on use of Anthrafilt for filters and sludge beds is contained in a revised pocket Manual issued by Anthracite Equipment Corp. For free copy write H. G. Turner, State College, Pa.

Filters, Vacuum

389. Continuous vacuum filters for dewatering sludge like those used in the new Cranston, R. I. sewage plant are described and illustrated in a 48-page booklet issued by The Eimco Corp., 634-666 South 4th West St., Salt Lake City, Utah.

Fire Hydrants

390. Specifications for standard AWWA fire hydrants with helpful instructions for ordering, installing, repairing, lengthening and using. Issued by M & H Valve & Fittings Co., Anniston, Ala

391. See listing No. 410.

Flow Meters

392. The primary devices for flow measurement—the orifice, the pilot tube, the venturi meter and others—and the application to them of the Simplex meter are described in a useful 24-page booklet (42A). Simplex Valve and Meter Co., 6750 Upland St., Philadelphia, Pa.

Gas Holders and Digesters

393. Clarifiers, sludge digesters and other tanks and gas holders for sludge gas. Graver Tank & Mfg. Co., Inc., 332 So. Michigan Ave., Chicago, Ill.

Gates, Valves, Hydrants

394. Gate, flap and check valves; floor stands and fittings. New catalog No. 34 gives detail information with dimensions for all types of new full line. M. & H. Valve & Fittings Co., Anniston, Ala.

395. Complete booklet with much worthwhile water works data describes fully Ludlow hydrants and valves. Sent on request. Ludlow Valve Mfg. Co., Troy, N. Y.

396. See listing No. 410.

Gauges

398. The full line of Simplex gauges for filtration plants are illustrated and described in catalog issued by Simplex Valve and Meter Co., 6750 Upland St., Philadelphia, Pa.

Laboratory Equipment

403. pH and Chlorine Control. A discussion of pH control and description of comparators, chlorimeters and similar devices. An 80-page booklet. W. A. Taylor & Co., 7301 York Road, Baltimore, Md.

Maintenance

404. "The Lubriplate Way" contains much valuable information on long-lasting Lubriplate lubricants which are especially adapted for difficult conditions such as parts that are immersed in sewage, water or steam. Write Lubriplate Division of Fiske Brothers Refining Co., 129 Lockwood St., Newark, N. J.

Manhole Covers and Inlets

405. Street, sewer and water castings in various styles, sizes and weights. Manhole covers, water meter covers, adjustable curb inlets, gutter crossing plates, valve and lamphole covers, ventilators, etc. Described in catalog issued by South Bend Foundry Co., Lafayette Boul. and Indiana Ave., South Bend, Ind.

Meters, Venturi

406. New bulletin illustrates Builders Air Relay system of transmission for the Venturi Meter which is particularly useful for liquids containing suspended solids like sewage. Eliminates corroson, clogged pipes, etc. Write Builders-Providence, Inc., Codding St., Providence, R. I.

Pipe, Cast Iron

408. Handbook of Universal Cast Iron Pipe and Fittings, pocket size, 104 pages, illustrated, including 14 pages of useful reference tables and data. Sent by The Central Foundry Co., 386 Fourth Ave., New York, N. Y.

409. Cast iron pipe and fittings for water, gas, sewer and industrial service. Super-deLavaud centrifugally-cast and pit-cast pipe. Bell-and-spigot, U. S. Joint, flanged or flexible joints can be furnished to suit requirements. Write U. S. Pipe and Foundry Co., Burlington, N. J.

410. "Cast Iron Pipe and Fittings" is a well illustrated 44 page catalog giving full specifications for their complete line of Sand Spun Centrifugal Pipe, Fire Hydrants, Gate Valves, Special Castings, etc. Will be sent promptly by R. D. Wood Co., 400 Chestnut St., Philadelphia, Pa

Pipe, Lock Joint

412. Lock Joint Reinforced Concrete Sewer Pipe. Pressure Pipe, Culvert Pipe, Centrifugal Pipe and Subaqueous Pipe is described and illustrated in bulletins available from Lock Joint Pipe Co., Ampere, N. J.

Pipe, Transite

414. Two new illustrated booklets, "Transite Pressure Pipe" and "Transite Sewer Pipe" deal with methods of cutting costs of installation and maintenance of pipe lines and summarize advantages resulting from use of Transite pipes. Sent promptly by Johns-Manville Corp., 22 East 40th St., New York, N. Y.

Pipe Joints Sewer

415. How to make a better sewer pipe joint of cement—tight, minimizing root intrusion, better alignment of joint. Permits making joints in water-bearing trenches. General instructions issued by L. A. Weston, Adams, Mass.

Pipe, 2-inch Cast Iron

417. Generously illustrated booklet describes McWane 2-inch cast iron pipe and its manufacture in streamlined pipe shop. Write McWane Cast Iron Pipe Co., Birmingham, Ala.

Pipe Joint Compounds

418. The uses of Tegul-Mineralead for bell and spigot pipe and G-K Sewer joint compound are described in a 16-page illustrated booklet issued by Atlas Mineral Products Co., Mertztown, Pa. Includes useful tables for estimating quantities needed.

419. "Hydrotite," self-caulking, sulphur base jointing compound for bell and spigot c.i. pipe and soil pipe. Also "Fibrex," sanitary packing, used like jute. For bulletins write Hydraulic Development Co., 50 Church St., New York, N. Y.

Pumps and Well Water Systems

420. Installation views and sectional scenes on Layne Vertical Centrifugal and Vertical Turbine Pumps fully illustrated and including useful engineering data section. Layne Shutter Screens for Gravel Wall Wells. Write for descriptive booklets. Advertising Dept., Layne & Bowler, Inc., Box 186, Hollywood Station, Memphis, Tenn

Meter Setting and Testing

430. The most complete catalog we have seen on setting and testing equipment for water meters—exquisitely printed and illustrated 48-page booklet you should have a copy of. Ask Ford Meter Box Co., Wabash, Ind.

Screens

434. Be assured of uninterrupted, constant automatic removal of screenings. Folder 1587 tells how. Gives some of the outstanding advantages of "Straightline Bar Screens" (Vertical and Inclined types). Link-Belt Co., 307 N. Michigan Ave., Chicago, Ill.

Sludge Drying and Incineration

440. "Disposal of Municipal Refuse." Complete specifications and description including suggested form of proposal; form of guarantees; statements and approval sheet for comparing bids with diagramatic outline of various plant designs. 18 pages. Address: Morse Boulger Destructor Co., 216-P East 45th St., New York N Y

442. Recuperator tubes made from Silicon Carbide and "Fireclay" Corebusters for maximum efficiency are described and illustrated in bulletin No. 11 issued by Fitch Recuperator Co., Plainfield National Bank Bldg., Plainfield, N. J.

443. Nichols Herreshoff incinerator for complete disposal of sewage solids and industrial wastes—a new booklet illustrates and explains how this Nichols incinerator works. Pictures recent installations. Write Nichols Engineering and Research Corp., 60 Wall Tower, New York, N. Y.

Softening

444. This folder explains the process of Zeolite water softening and describes and illustrates the full line of equipment for that purpose made by the Graver Tank & Mfg. Co., 332 So. Michigan Ave., Chicago, Ill. Includes flow charts, tables and other valuable data. Write for a copy of this instructive folder.

445. Water Softening. The use of the Spaulding Precipitator to obtain maximum efficiency and economy in water softening is described in a technical booklet. Permutit Co., 330 W. 42nd St., New York, N. Y.

Sprinkling Filters

447. Design data on sprinkling filters of Separate Nozzle Field and Common Nozzle Field design as well as complete data on single and twin dosing tanks, and the various siphons used in them, for apportioning sewage to nozzles. Many time-saving charts and tables. Write Pacific Flush Tank Co., 4241 Ravenswood Ave., Chicago, Ill.

Swimming Pools

448. Data and complete information on swimming pool filters and recirculation plants; also on water filters and filtration equipment. For data prices, plans, etc., write Roberts Filter Mfg. Co., 640 Columbia Ave., Darby, Pa.

Taste and Odor Control

449. "Taste and Odor Control in Water Purification" is an excellent 92-page, illustrated booklet covering sources of taste and odor pollution in water supplies and outlining the various methods of treatment now in use. Every water works department should have a copy. Write Industrial Chemical Sales Div., 230 Park Ave., New York, N. Y.

450. Technical pub. No. 207 issued by Wallace & Tiernan Co., Inc., Newark, N. J., describes in detail taste and odor control of water with BREAK-POINT Chlorination, a method of discovering the point at which many causes of taste may be removed by chlorination with little or no increase in residual chlorine. Sent free to any operator requesting it.

Treatment

453. "Safe Sanitation for a Nation," an interesting booklet containing thumbnail descriptions of the different pieces of P.F.T. equipment for sewage treatment. Includes photos of various installations and complete list of literature available from this company. Write Pacific Flush Tank Co., 4241 Ravenswood Ave., Chicago, Ill.

454. A full line of equipment for sewage disposal including clarifiers, chemical treatment plants, rotary distributors, gas holders and many other pieces of equipment are described in a new bulletin just issued by Graver Tank & Mfg. Co., 332 So. Michigan Ave., Chicago, Ill.

455. New booklet (No. 1642 on Link-Belt Circuline Collectors for Settling Tanks contains excellent pictures; drawings of installations, sanitary engineering data and design details. Link-Belt Company, 2045 W. Hunting Park Ave., Philadelphia.

456. New 16-page illustrated catalog No. 1742 on Straightline Collectors for the efficient, continuous removal of sludge from rectangular tanks at sewerage and water plants. Contains layout drawings, installation pictures, and capacity tables. Address Link-Belt Co., 2045 West Hunting Park Ave., Philadelphia, Pa.

457. New illustrated folder (1942) on Straightline apparatus for the removal and washing of grit and detritus from rectangular grit chambers. Address: Link-Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.

458. "Sedimentation with Dorr Clarifiers" is a complete 36-page illustrated catalog with useful design data. Ask The Dorr Company, 570 Lexington Ave., New York, N. Y.

459. A combination mechanical clarifier and mechanical digester, The Dorr Clarigester, is explained and illustrated in a bulletin issued by The Dorr Company, 570 Lexington Ave., New York, N. Y.

461. Prefloccculation without chemicals with the Dorrco Clarifloculator in a single structure is the subject of a new booklet issued by The Dorr Company, 570 Lexington Ave., New York, N. Y.

462. Dorrco Monorake for existing rectangular sedimentation tanks, open or closed, is described and illustrated in a new catalog sent on request. The Dorr Co., 570 Lexington Ave., New York N Y.

464. Rotary Distributors. Bulletin describes Infilco rotary distributors and automatic dosing siphons. Infilco, Inc., 325 W. 25th Place, Chicago, Ill.

465. Grit Washers and Collectors, by Jeffrey are built in three types: scraper, V-bucket and combination. For full details ask for Jeffrey Catalog No. 703-A. Jeffrey Mfg. Co., 948-99 No. Fourth St., Columbus, Ohio.

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466. Flocculation with Floctrols. For details on controlled flocculation, tapered mixing, practical elimination of short circuiting, rapid settling of properly flocculated solids write for Catalog No. 703-A. Jeffrey Mfg. Co., 948-99 No. Fourth St., Columbus, Ohio.

Underdrains, Trickling Filter

468. Illustrated bulletin describes the Natco Unifilter block of glazed, hard burned clay for underdraining filter beds. Write National Fireproofing Corp., Pittsburgh, Pa., for free copy.

Valves (See Gates, Air Release, etc.)

Waste Elimination

469. Full information on the Pitometer Survey—a complete check-up on your water plant to reveal hidden sources of waste—will be sent promptly by The Pitometer Co., 48 Church St., New York, N. Y.

Water Treatment

470. If you have a water conditioning problem of any kind, write Graver Tank & Mfg. Co., 332 So. Michigan Ave., Chicago, Ill., who manufacture all types of conditioning equipment and will be pleased to make recommendations.

472. Bulletin describes stabilizing lime-softened water by recarbonation, discussing gas production, washing, compressing, drying, and applying the CO(2). Infilco, Inc., 325 West 25th Place, Chicago, Ill.

Water Works Operating Practices

490. "Important Factors in Coagulation" is an excellent review with bibliography and outlines of latest work done in the field. Written by Burton W. Graham and sent free on request to Stuart-Brumley Corp., 516 No. Charles St., Baltimore, Md.

Water Service Devices

500. Data on anti-freeze outdoor drinking fountains, hydrants, street washers, etc., will be sent promptly on request to Murdock Mfg. & Supply Co., 426 Plum St., Cincinnati, Ohio.

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